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D. J.

“Of all the natural objects of the world, the surface of the earth is that with which we are best acquainted, and most interested. It is here that man has the disposal of nature so much at his will ; but here, man, in disposing of things at the pleasure of his will, must learn by studying nature what most will conduce to the success of his design, or to the happy economy of his existence.”—HUTTON'S *Theory of the Earth*.

“In considering the study of physical phenomena, not merely in its bearings on the material wants of life, but in its general influence on the intellectual advancement of mankind, we find its noblest and most important result to be a knowledge of the chain of connection by which all natural forces are linked together and made mutually dependent upon each other ; and it is the perception of these relations that exalts our views and ennobles our enjoyments.”—HUMBOLDT'S *Cosmos*.

P R E F A C E.

IN connection with his Text-Books of Geology, the Author has long meditated the production of two similar works on the closely-allied science of Physical Geography. The two subjects are most intimately connected; Geology forming, as it were, the groundwork of Geography—and Geography, on the other hand, becoming the field in which the operating causes of Geology are most obviously and intelligibly at work. The one becomes, in fact, the complement of the other; and the student of Geology can have no better preliminary training than a systematic course of Physical Geography—while the student of Geography cannot more readily ascend to the higher problems of his science than through the teachings of Geology. Though thus closely related, the two sciences may be studied, each on its own basis; and a large amount of knowledge may be acquired respecting the geographical conditions of the world—its lands, waters, and atmosphere; their mutual actions and reactions; the distribution of mineral, vegetable, and animal productions; and the bearings of these on the intellectual and social progress of man,—without knowing more of Geology than merely being able to appreciate and apply its more obvious deductions.

Convinced of this, the Author has endeavoured to produce

an Introductory and an Advanced Text-Book of Physical Geography, in accordance with the requirements of modern education, and the advancing state of the natural sciences. As the Introductory is not a mere narration of dry facts, to be irksomely committed to memory, but an outline of phenomena and principles to be read and reasoned ; so the Advanced, avoiding the argumentative character of a scientific essay, aims at something more than a bulky compilation of disjointed descriptions, and not unfrequently contradictory statements. In both instances a systematic treatment has been strictly adhered to ; and while the Introductory may meet the requirements of junior students, and those who cannot command time for an extended course, the Advanced, it is hoped, will satisfy the wants of senior students, as well as of those who merely seek a general acquaintance with the natural phenomena of our planet. The explanation of principles, rather than a detail of facts, has been a main object throughout, that the student may be enabled to apply them to his own observations and readings—readings that become every year more extensive, from the increasing facilities for travel in remote and imperfectly known regions.

To assist the student in the comprehension of his subject, an extensive Glossary of Terms has been appended, and a number of illustrations inserted in the text ; but the accompaniment of maps has been rendered unnecessary by the recent publication of several excellent Atlases of Physical Phenomena.

EDINBURGH, *June* 1864.

THIRD EDITION.

IN the present Revision I have had respect not only to the requirements of the student desirous of making himself acquainted with the newest discoveries and opinions in Physical Geography, but also to the needs of those teachers who intend to use this work in class, in conjunction with the Author's 'Introductory Text-Book' upon the same subject. While, therefore, the chief results of recent research and speculation in the science have been incorporated in the body of the work, as few alterations as possible have been made in its original text and arrangement. Each paragraph (with the exception of those of the last two chapters) is devoted to the same subject as in former editions, much of the new matter has been added in the words of the last edition of the 'Introductory Text-Book,' and the two works have been brought into general harmony throughout. The Chapters on Geology, Mountain Systems, Oceans and Seas, Climatology and Animal Life, have been extended. The information derived from Physics, Meteorology, Biology, and Recent Geographical Discovery, has been brought down to date. Some new maps have been inserted, and the copious glossary corrected and enlarged.

CHARLES LAPWORTH.

MASON SCIENCE COLLEGE, BIRMINGHAM,
December 1882.

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PHYSICAL GEOGRAPHY.

I.

INTRODUCTORY OUTLINE.

Aim and Scope of the Science.

1. THE science of Geography embraces all that can be learnt of the superficial aspects of our globe—its lands and waters, their extent and configuration, their varied conditions and climate, the atmosphere above them ; and, finally, the distribution of the plants and animals by which they are respectively peopled. It leaves the allied science of Geology to determine the nature of the rocky structure which underlies the earth-surface, and to read the history of the several mutations that structure has undergone in the ages that are past. It confines itself essentially to the description of the external features and conditions of the earth-surface, as they exist at the present day ; and endeavours to explain the causes by which these conditions are produced, and the purposes for which they are apparently maintained.

2. A science embracing so wide and varied a subject will most naturally present itself under several heads or departments ; and thus we have what is termed *Mathematical Geography*, which devotes itself to the size, form, motions, and general divisions of the earth as a planet, forming part of the solar system ; *Political Geography*, which relates to the arbitrary subdivisions of the earth-surface into empires, kingdoms, and states, with their populations, manners, religion, laws, industry, commerce, and other features distinctive of such subdivisions ; *Descriptive* or *General*

Geography, which restricts itself to a mere account of the external aspects of the lands and waters—their extent and configuration, their scenery, life, and other obvious features—without inquiring into the causes that produce these appearances; and lastly, *Physical Geography*, which, while it embraces all the natural conditions of the lands and waters depicted by Descriptive Geography, proceeds further to inquire into the causes that produce these results, and by which they are in the course of nature continually reproduced within certain limits of change and modification. The configuration of every land and sea—the extent and altitude, the soil, the rivers, the climate, the animal and human inhabitants of the former, and the extent and depth and movements of the latter—act and react upon one another. It is the highest aim of Geography to analyse these correlations, to sift the casual from the essential, and to arrive at an intelligible expression of the laws by which the whole is controlled and directed.

3. Physical Geography is thus the highest department of the science, its aim being not only to describe the external aspects of the terraqueous globe, but to inquire into those conditions of position, altitude, soil, heat, moisture, and the like, which govern the distribution of plants and animals on the land, and those conditions of depth, composition, and temperature, which regulate in a similar manner the distribution of plants and animals in the ocean. The Land, its continents and islands, its mountains and valleys, its soil and climate, its scenery and life-arrangements; the Ocean, its seas and bays, its shoals and depths, its composition and temperature, its aspects and life-dispersion,—are the special objects of Physical Geography; and its highest aim is the discovery and expression of those laws which regulate the action and reaction of land, water, and atmosphere in the production of physical phenomena. Physical Geography thus rises above the mere description of external appearances, and seeks to explain the causes that produce them—arranging the whole into a system of world-machinery whose modes of action can be understood, and whose results it is possible to determine. In the eloquent language of the author of ‘*Earth and Man*’ (M. Guyot)—“Geography ought to be something different from a mere description. It should not only describe, it should compare, it should interpret, it should rise to the *how* and the *wherefore* of the phenomena which it describes. It is not enough for it coldly to *anatomise* the globe, by merely taking cognisance of the arrangement of the various parts which constitute it. It must endeavour to seize those incessant mutual actions of the different portions of physical nature upon

each other, of inorganic upon organised beings, upon man in particular, and upon the successive developments of human societies."

4. Rising to this conception of his science, and viewing the beautiful and diversified field before him, the student of Geography meets a problem in every phenomenon that presents itself, and finds a solution in every incident that occurs. Why, for instance, do two countries, lying within the same parallels of latitude, present such differences in climate? Why are the higher mountain-peaks perpetually enveloped in snow, while the lower ridges are clothed in verdure and blossom? Why is one region of a continent arid and rainless, while another is deluged with periodical torrents? Why do the winds in certain latitudes blow steadily and for weeks in one direction, while in another they are fitful and irregular? Why should one expanse of ocean be still and tideless, while another swells and falls with tides, and is traversed by currents? Why should the plants and animals that flourish in one region, dwarf and die out if transferred to another equally fertile in soil and genial in climate? Why should the men at the mountain-foot be tillers of fields and dressers of vineyards, while those a thousand feet higher are herdsmen and shepherds? Or why should one country be the scene of busy industry and successful commerce, of intellectual activity and mental culture, while another, as fair and even more fertile, remains the mere squatting-ground of indolent, dependent, and semi-civilised hordes? These and a thousand similar questions press themselves upon the attention of every geographical observer: and while the facts may be detailed with clearness and accuracy by Descriptive Geography, we must turn to Physical Geography for a rational solution of the phenomena presented—the order in which they occur, and the causes to which they appear to be more immediately dependent.

5. In the prosecution of his subject the student of Physical Geography appeals to Astronomy for what relates to the figure, size, motions, and other primary conditions of our planet; to Geology for what relates to the structure and constitution of the rocky crust, which forms the groundwork of all Geographical diversity; to Meteorology for much that belongs to climate and its allied phenomena; while from Chemistry and Physiology he derives important aid in dealing with the nature, growth, and dispersion of plants and animals. Here, for example, is an island in the ocean; what is its position on the earth's surface—that is, its latitude and longitude; when will its sun rise and set in Greenwich time; what are the limits of its seasons; when will its tides ebb and flow; what is the force of gravity

at its surface? Strictly speaking, these questions belong to Astronomy and Mathematics ; but the geographer, availing himself of the aid of these sciences, appeals to them for the solution of his problems. Again, this island is rocky and precipitous towards the north and west, while towards the south and east it falls away in gentle slopes and terraces. Its north-western section presents, in the main, a series of basaltic crags and rocky hill-tops, while the south-eastern consists of clays and loams that lie on upturned strata of sandstones, limestones, and shales. Up among its hills there is a small circular lake or tarn ; while along the junction of the sandstones and basalt numerous springs rise and find their way to the low lands beneath. This is the structure of the island, and its explanation can only be arrived at by the aid of Geology. Further, while its hill-tops are often enveloped in mists, the lower slopes rejoice in sunshine ; and not unfrequently, when the heights are covered with snow, the low grounds are fresh and open. The rainfall on its western coast is several inches more than that on the east ; and the north-east winds are cold and parching, while the south-west are warm and laden with moisture. This is its Climatology ; and Meteorology furnishes the geographer with the means of harmonising these contrasting phenomena. Still further, the plants that flourish on its basaltic crags are never found on the clayey slopes below ; while even on the slopes and terraces different plants affect different soils, though exposed to the same sunshine and moisture. Chemistry and Physiology account for these results. Physical Geography, while it describes and harmonises the whole, must therefore own her obligations to many allied departments of natural science. Though drawing, however, in this manner from other sciences, it by no means follows that the student of Physical Geography should be deeply read in Astronomy, Geology, or Meteorology. All that is necessary is, that he be able to perceive the connection and interbearings of these sciences, and be capable of appreciating the importance of their deductions in so far as they relate to his own special study.

Theoretical and Practical Bearings of Geography.

6. The value of such a science must be obvious to the most casual observer. To determine the relative extent of the land and water that constitute the terraqueous surface of our globe—the varying altitudes of the one and the depths of the other, the climates of the one and the winds and currents that traverse the

other, with the infinitely-diversified mineral, vegetable, and animal productions of both—is not only a source of high intellectual enjoyment and culture, but a task of prime industrial necessity. This globe is the sole scene of man's earthly labours—his cradle, the theatre of his life-actions, his grave ! Scattered over its surface, separated by sea and mountain, enjoying different climates, and placed in proximity to different mineral, vegetable, and animal products, it is a natural necessity that different nations should trade and barter with each other. To ascertain the peculiarities of this varied surface, to learn the variety of its products—to know all, in fine, that relates to the home we tenant, and the necessities and comforts with which it is furnished, as well as the obstacles or facilities that lie in the way of obtaining them—is the sum and substance of Geography. The observation and reasoning required in geographical research, the amount of information obtained, and the curiosity gratified by faithful descriptions of distant and diverse regions, constitute, on the one hand, its theoretical value ; acquaintance with their mineral, vegetable, and animal products, now so indispensable to civilised existence, the conditions under which these occur, the facilities with which they can be obtained, form, on the other hand, its economic or practical importance.

7. To the navigator dependent on the winds and currents of the ocean, what is more necessary than a knowledge of their times, directions, and limits ? The determination of shoals and sandbanks, of sunken rocks and reefs, is no doubt highly valuable ; but it is a higher effort of philosophy to determine the causes and courses of the wind and water currents—to teach the sailor how to shun the storms of the one, and to cast himself on the favouring stream of the other. To the pioneer and settler in new lands, what is more important than a knowledge of the climate, the seasons, and the products of his adopted home ? or what more valuable than the teachings of Physical Geography to the merchant-traveller in search of new objects of enterprise and new sources of wealth ? To the botanist and zoologist, who deal with the strictly scientific aspects of natural history, as well as to the gardener and farmer, who seek to naturalise the plants and animals of different regions, there is no science whose bearings are so immediate as that which reveals the geographical distribution of life, and the causes which determine the order of that distribution. To the physiologist and psychologist who would study the influence of climate and other external conditions on health as well as on mental character ; and to the political economist and statesman who have to deal with the peculiarities of different

nations and the products of their countries, Physical Geography becomes a science of direct and important interest. Combining, therefore, its theoretical with its practical bearings, our science has paramount claims alike on the attention of the philosopher, the statesman, the sailor, the farmer, the merchant, and the manufacturer.

Hints to the Student.

8. The object of the present treatise is to offer an outline of the science of Physical Geography in its higher bearings. The student who earnestly desires to master this outline, should confirm the statements of the text step by step, by reference to the maps of his atlas. By this process his difficulties will be more easily overcome, while the facts will be fixed more clearly and permanently on the memory. The study of General Geography—the positions of towns, courses of rivers, heights of mountains, and the like—is for the most part little better than a task of memory. Physical Geography, on the other hand, requires reasoning at every step, and the student will find his reasonings greatly assisted not only by the systematic use of his atlas, but by the habit of appealing to the phenomena presented by his own immediate district. There are few localities, however limited, that do not present their alternations of hill and dale, of lake and river, of warm winds and cold winds, of periods of drought and periods of rainfall, of plants that love the marsh and others that thrive only in the thirsty upland. By noting such distinctions, and the causes concerned in their production, the mind will be better prepared for the comprehension of the phenomena of wider and more varied regions. As the botanist, zoologist, and geologist find the objects of their studies in every walk through the fields around them, so the student of Physical Geography will find the illustrations of his science in every locality he may visit. Every district has its own features of high-land and low-land, its streams and lakes and rivers, its peculiar winds and rains and frosts, its special arrangements of plants and animals; and he who understands best the governing causes of these local peculiarities will be best able to deal with the general problems of Physical Geography. There is nothing fortuitous in the economy of our planet: every breeze that blows, every cloud that sweeps across the firmament, and every shower that falls—fickle, uncertain, and local as they may appear—is as much the result of law and law-directed forces as the rising and falling of the tides or the revolutions of the planets. Impressed with this conviction,

and seeing how closely every incident in nature is connected with another, the student will consider no occurrence as too trivial, and no fact as too insignificant, to deserve his attention. To the mind imbued with this belief, the most fitful and uncertain phenomena assume the character of regularity and order, and the determination of the law of their recurrence becomes a hopeful and exhilarating pursuit. "Wherever our home is," says Carl Ritter in his 'Comparative Geography,' "there lie all the materials which we need for the study of the entire globe. Humboldt hints at this when he says in his 'Kosmos,' 'Every little nook and shaded corner is but a reflection of the whole of Nature.' The roaring mountain-brook is the type of the thundering cataract; the geological formations of a single little island suggest the broken coast-lines of a continent. The digging of every well may contribute to our knowledge of the earth's crust; the excavations made in the construction of railways may be a ceaseless source of instruction. In the structure of a blade of grass, of a rush, of a single monocotyledon, may be studied in miniature the palm-tree, prince of the tropics; in the mosses and lichens on our walls the stunted growths of mountain-tops may be investigated. A small range of hills may be taken as the type of the loftiest Cordillera. The eye may be easily trained to see all the greater in the less. The study of our own district is the true key to the understanding of the forms and phenomena of foreign lands. Whoever has wandered through the valleys and woods, and over the hills and mountains, of his own country, will be capable of following a Humboldt in his wanderings over the globe. He, and he alone, will be able, with true appreciation, to accompany travellers through all foreign lands. *The very first step in a knowledge of geography is to know thoroughly the district where we live.*"

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding paragraphs we have endeavoured to show that the object of Physical Geography is to describe the external conditions of the globe, and discover the causes by which they are maintained or modified. It treats of the earth's surface as composed of land and water, determines their extent and configuration, their altitude and depth, the climate and other conditions that influence the growth and distribution of the plants and animals by which they are respectively peopled, and, rising above these,

endeavours to account for the mental and social peculiarities of different nations as seemingly dependent on external phenomena. Deriving from Astronomy what relates to the figure, dimensions, motions, and other primary features of our planet ; from Geology its description of the structure and composition of the rocky crust ; from Meteorology the explanation of proximate causes of the diversity of climates ; and from Chemistry and Physiology their account of the more intimate nature of vegetable and animal life, —Physical Geography proceeds to apply these adjuncts to its own proper field of inquiry, and from the whole deduces a rational and connected account of the cosmical phenomena by which we are surrounded. “ Its ultimate aim,” in the words of the illustrious Humboldt, “ is to recognise unity in the vast diversity of phenomena, and by the exercise of thought and the combination of observations, to discern the constancy of phenomena in the midst of apparent changes.” As a science of observation and deduction in connection with the external conditions of the beautiful planet we inhabit, it possesses high intellectual attractions ; and as bearing on its mineral, vegetable, and animal products—their abundance, distribution, and capabilities of dispersion—it becomes to civilised nations a study of prime industrial importance. The more extensive and intimate our knowledge of terraqueous phenomena, the more certain and reliable the deductions of Physical Geography. The more fully man knows the economy of the globe, the more fully he can avail himself of its favours, and the more closely can he direct his operations in conformity with its requirements.

II.

THE EARTH—ITS GENERAL OR PLANETARY RELATIONS.

Figure, Motions, Dimensions.

9. By the general relations of the earth are meant those primary conditions of form, size, density, motion, and the like, which belong to it as a member of the Solar System. From these conditions arise all those multifarious actions and reactions that take place on its surface—the alternations of night and day, heat and cold, summer and winter, growth and decay, the winds and motions of the atmosphere, the tides and currents of the ocean, and, in fact, all that confers on it geographical diversity and modification. Thus, on its axial rotation depends the recurrence of light and darkness; from its revolution round the sun arises the succession of the seasons, with all their varied effects on vegetable and animal life; from the varying effects produced by the sun's heat upon the terraqueous surface and atmosphere result the multifarious phenomena of what we call weather and climate; while from the attraction of the sun and moon, and the earth's own proper motion, spring the flow and ebb of the tides, and the other great currents of the ocean. The consideration of these conditions belongs, no doubt, more especially to Astronomy and Physics, but as much may be here summarised as will enable the student to lay the foundation, as it were, of his own special science.

10. As we have already pointed out, the province of Physical Geography is not merely to observe and describe, but to explain and determine. Here is a globe revolving and rotating in obedience to the laws of gravitation and attraction; and as motion is inseparably associated with change—change of place or change of condition—the nature of these changes, and the secondary results arising therefrom, constitute the legitimate themes of our science. Manifested on or near the accessible surface, these phenomena

• become apparent to every observer ; but the producing causes are often so complicated by action and reaction on each other, that without a knowledge of the general relations of the earth, it would be impossible to arrive at a satisfactory determination. As there is no independent existence in nature, so it is necessary to have some idea of the whole ; and as our planet is but one of a brotherhood, it is necessary to the comprehension of its individual constitution to have some notion of the relations that subsist between the fraternity. It is for this reason that Geography appeals to Astronomy for a knowledge of the planetary conditions of the earth, in as far, at least, as these appear to bear on its superficial phenomena.

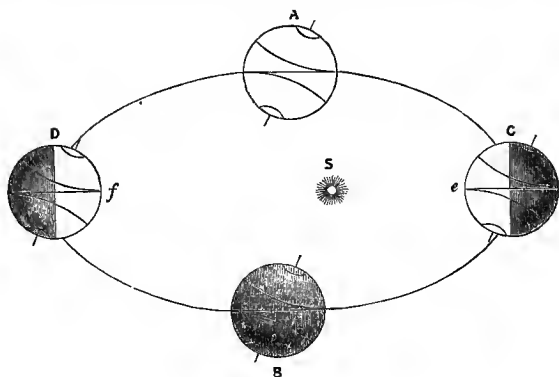
11. Astronomers have determined that the earth we inhabit is one of a number of planets that revolve, at different distances and with different velocities, round the sun as a common centre, constituting what is termed the *Solar System*. These bodies—some of which are nearer the sun than our earth, and others more remote, some vastly larger, and others smaller—are all nearly spherical in form, and move from west to east, in courses or *orbits* more or less circular. The mean distance of the earth from its central orb is 91,430,000 miles, or, in round numbers, ninety-two millions. Its time of revolution round the sun is about $365\frac{1}{4}$ days—or, more precisely, 365 days, 6 hours, 9 minutes, and 10 seconds—and this period of revolution we designate *a year*. Besides this annual revolution round the sun, the earth rotates or turns on its own axis in 24 hours—or, more exactly, in 23 hours, 56 minutes, and 4 seconds—and this period of rotation constitutes *a day*. In other words, the earth rotates three hundred and sixty-five times during the course of a single revolution, and thus the more frequent and obvious motion of daily rotation has been taken as the unit of measurement for the larger and less apparent. In these movements of annual revolution and daily rotation, the earth, like several other of the primary planets, is attended by a minor or secondary body, which revolves around her, as she revolves around the great central luminary of the system. This secondary planet or *satellite* is the Moon, which is 2160 miles in diameter, and which completes her revolution round her parent orb (at a distance of 238,000 miles) in 27 days, 8 hours—or, in round numbers, in 28 days, or one lunar *month*. All these motions and times of motion are determined and influenced by the mutual attraction and gravitation of the sun and planets ; and it is by the same great forces that all the heavenly bodies that lie beyond our system are held in harmonious order, and, in all likelihood, in analogous fraternities. As the secondary planets

revolve round their primaries, and these, again, round the sun, so the solar system itself may revolve round some vaster centre, and this order of things through systems and centres that baffle the grasp of our finite conceptions. As at present known, this solar system consists of the great centre or *sun*; eight large or primary *planets*—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune; above two hundred ascertained *planetoids*, or small planet-like bodies (generally known as the *Asteroids*), between the orbits of Mars and Jupiter, and occupying, it has been suggested, the place of a large primary; twenty secondaries or *satellites*, revolving round their primaries; an unknown number of *comets*, which move round the sun in extremely elliptical orbits, and consequently are seen only at widely distant periods; and several groups of *meteors*, whose orbits are not well defined, and which become visible only by coming in contact with, and by being ignited in, our atmosphere. As the secondary planets revolve round their primaries, and these, again, round the sun, so the solar system itself may revolve round some vaster centre, and this order of things through systems and centres that baffle the grasp of our finite conceptions. The sun itself is about 852,900 miles in diameter, and revolves upon its own axis in a period calculated at 25 days, 0 hours, 17 minutes. The names of the planets, their diameters, distances from the sun, times of revolution and rotation, and number of satellites, are exhibited in the following table:—

Names and Order of Planets.	Diameters in English Miles.	Distance from Sun in Miles.	Revolution in Days.	Rotation in Days and Hours.	No. of Satellites.
				D. H. M.	
Mercury, . .	3,058	35,392,000	87.969	1 0 5	...
Venus, . .	7,510	66,134,000	224.700	0 23 21	...
Earth, . .	7,926	91,430,000	365.256	1 0 0	1
Mars, . .	4,363	139,311,000	686.979	1 0 37	2
Asteroids, . .	...	250,000,000	2,000.000	...	...
Jupiter, . .	84,846	475,692,000	4,332.584	0 9 55	4
Saturn, . .	70,136	872,137,000	10,759.219	0 10 29	8
Uranus, . .	33,247	1,753,869,000	30,686.820	0 9 30	4
Neptune, . .	37,276	2,745,998,000	60,126.720	...	1

12. The sun being the great source of light, heat, and other ethereal influences, it necessarily follows that, during the earth's rotation on her axis, only one half of her surface can be exposed at a time to these influences, and hence the alternations of *day* and *night*, and all the phenomena that accompany these alterna-

tions. But day and night are of unequal and varying length at certain localities, according to the *seasons*; and these seasonal successions are caused by the fact, that in performing her annual revolution round the sun her axis is not perpendicular, but inclined at an angle of 66 degrees 27 $\frac{1}{4}$ minutes to the plane of her orbit. The accompanying diagram will assist in explaining the consequences of this obliquity of axis. Thus S is the Sun, with the earth represented at four different points in her annual orbit. At A and B the light and heat of the sun strike perpendicularly upon the earth's surface at the equator, or middle line, and consequently day and night are of equal duration. At any intermediate position, day and night are respectively lengthened and shortened: when at C, the north pole is in darkness; and when at D, the south pole is in the same state. When the point presented to the sun is at *e* (which is on the 22d December), it is midsummer to all the southern parts of the earth, and midwinter to all the north; but as the exposed part advances towards the point



The Seasons.

f, the northern regions gradually receive more and more heat, till, on the 21st of June, it becomes their midsummer. Having glanced at the main systemal motions of the earth that regulate our days, years, months, and seasons, we shall now advert to her own proper dimensions, as determined by the astronomer and mathematician.

13. The body which thus rotates on its own axis while it revolves round the sun, and is in turn revolved around by the moon, is not, strictly speaking, a sphere or globe, but a *spheroid*, or body of a sphere-like form. A diameter taken along its axis, or the ideal line round which it rotates, is only 7899.170 miles,

while one taken in the opposite direction is 7925.648 miles. The one diameter thus exceeds the other by about $26\frac{1}{2}$ miles, thereby causing a deviation from the true globular form, and producing what mathematicians term an *oblate spheroid*—that is, a figure flattened in the direction of its axis, and bulging out all around somewhat in the shape of an orange. Such a figure can be readily produced by rapidly spinning a ball of yielding material, like soft clay or putty, round its own axis, when the tendency which all revolving bodies have to fly off from the centre (centrifugal force) causes the mass to bulge out at the rotating circumference and to flatten in proportion at both ends or *poles* of the axis. To this centrifugal force arising from rotation, and possibly to some original yielding condition of the earth's mass, its oblate or spheroidal form is usually ascribed. The earth's mass is kept together by the force of *gravitation*; and had it remained at rest, its form would have been perfectly spherical; but the moment it began to turn on its own axis, the particles of its mass began to obey another law—viz., that of *centrifugal force*, which exerts itself at right angles to the axis of rotation, and increases in proportion to the rapidity of rotation and to the square of the distance from that axis. Hence the greater bulging out of the earth's mass at the equator, where the distance from the axis is greatest; and hence also the gradual declension of centrifugal force as we proceed towards the poles. Gravitation and centrifugal force are thus the two great counteracting powers by which the earth is sustained in its present spheroidal form; and any variation in its dimensions, density, or velocity of rotation, would be accompanied by a proportional deviation from its existing shape. The ordinary observer has many proofs of the general spherical form of the earth, among which may be mentioned the following: 1. As a vessel sails away from the land, we first lose sight of her hull, next of her lower or main sails, and lastly of her topsails and pennants, thus clearly showing that she is passing over a convex or bulging surface. 2. The reverse of this also holds true; for the mariner, as he approaches the land, first sees the mountain-tops, and on gradually nearing it, the lower grounds stage by stage make their appearance. 3. Had the earth's surface been flat, it would have been all at once illuminated by the rays of the sun; but being convex or round, each place, as it turns from west to east, has its sunrise, noon, sunset, and night in succession—one half of the globe being thus always in light while the other is in darkness. 4. In travelling any considerable distance, either north or south, new stars gradually come into view in the direction to which the traveller is advancing, while others

disappear in the direction from which he is receding. 5. Many navigators, by constantly sailing in one direction, or nearly so, whether due east or due west, have returned to the port from which they set out, thus making what is termed the *circumnavigation* of the globe. 6. In consequence of the round form of the earth, the dip or depression of the horizon is about 8 inches per mile, and on this account engineers in cutting canals have to make an allowance for a dip of this extent in order to keep the water at a uniform level. 7. The shadow which the earth casts on the moon during an eclipse is always circular. 8. And lastly, the earth belonging to a system or brotherhood, the other members of which are globular, the fair presumption is, that she also is of the same form.

14. Calculating from the dimensions given in the preceding paragraph, the *mean diameter* of the earth will be 7,912.409 miles, and its *mean circumference* or girth 24,858 miles. It is usual, however, to speak in round numbers, of the diameter being 8000; the radius, or distance from the surface to the centre, as 4000; and the circumference as 25,000 miles. The superficial area of a globe of these dimensions amounts to 197 millions of square miles; and of these about 51 millions consist of land, and 146 millions are occupied by water. The proportion of land to that of water may therefore be said to be, in round numbers, as *one to three*; or, in other words, while one-fourth of the earth's surface consists of dry land, the other three-fourths are covered by the waters of the ocean. The *solid contents* of the mass have, in like manner, been computed to exceed 260 thousand millions of cubic miles—an amount which, though expressible in figures, is altogether beyond the grasp of human conception.

Some of the more important elements of the remaining members of the solar system are given in the following Table:—

	Volume, Earth's as 1.	Mass, Earth's as 1.	Density, Earth's as 1.	Gravity at Surface, Earth's as 1.	Bodies fall in one second.
					Feet.
Mercury, .	0.058	0.065	1.12	0.432	6.953
Venus, . .	0.855	0.885	1.03	0.982	15.805
Earth, .	1.000	1.000	1.00	1.000	16.095
Mars, . .	0.168	0.108	0.70	0.387	6.229
Jupiter, .	1233.205	300.860	0.24	2.611	45.024
Saturn, . .	696.685	89.692	0.13	1.141	18.364
Uranus, . .	74.199	12.650	0.17	0.716	11.524
Neptune, .	105.575	16.773	0.16	0.756	12.168
Moon, .	0.020	0.012	0.607	0.165	2.65

Density, Temperature, Atmosphere.

15. The density of the globe, as compared with the materials at its surface, has been determined with considerable precision. The average or mean density of the most prevalent rocks (granites, greenstones, limestones, sandstones), is about $2\frac{1}{2}$ times that of water at a temperature of 60° Fahrenheit ; while the density of the whole mass of the globe, as determined by torsion-balance, plumb-line, and pendulum experiments, is $5\frac{1}{2}$ times that of water. It has been argued from this that the interior of the earth cannot be composed of the same materials that constitute its outer portions ; for these, under the law of gravitation, would be so compressed at the depth of a few miles as to give a greater mean density to the whole mass than it actually possesses. Thus it has been calculated that air, at the depth of 34 miles from the surface, would become as heavy as water ; that water, at the depth of 362 miles, would be as dense as quicksilver ; and that the density of marble at the centre of the earth would be 119 times greater than what it is at the surface. Either, then, the interior of the earth is composed of materials differing altogether in nature from those known at its surface, or the compression of gravitation must be counteracted by some highly expansive force, such as heat, so as to maintain the mean density which astronomy and physics have determined.

16. Closely connected with the density of the globe is its temperature, or the amount of heat that pervades it. As one of the orbs of the solar system, the earth has a variable, superficial, or atmospheric temperature ; and, judging from volcanic action, there is also a higher and more remarkable interior or central temperature. Respecting the *superficial temperature*, which constitutes the great theme of climatology, to be noticed hereafter (Chap. XII.), it may be stated in the meantime, that it is influenced from day to day, and from season to season, by the heat of the sun ; that it varies according to the latitude, being greatest at the equator, and gradually decreasing towards the poles ; that it is greatly modified by the extent and distribution of sea and land—the sea and sea-coasts being more equable than inland continents, which experience extremes of heat in summer, and extremes of cold during winter ; that it is also modified by the absorbent or radiating nature of the soil, according as this is dark or light coloured, dry or moist, porous or compact ; and, lastly, that it is notably affected by elevation above the mean level of the sea—the higher being the colder regions.

17. The *temperature of the accessible crust*, on the other hand,

is affected either by the direct heat of the sun, by heat generated chemically among its own materials, or by heat derived by conduction from the interior. During summer, for instance, the earth is warmed to a certain depth by the heat of the sun; during winter this heat is given off to the surrounding atmosphere; and though the heat of one summer and the cold of one winter may differ from the heat and cold of others, still, on an average of seasons, the results are pretty equable. It may therefore be stated in general terms, that in summer the crust of the earth, at small depths, is colder than at the surface; that during winter the crust at these depths is warmer than at the surface; but that, in temperate regions, at the depth of 80 or 90 feet, the variations of summer and winter become wholly insensible. By many experiments in Scotland, France, Belgium, and Germany, which have been carefully instituted by Leslie, Quetelet, Forbes, and others, it is found that the middle of summer and winter, so to speak, occur—

at the surface, in July and January;
 3 feet deep, in August and February;
 12 feet deep, in October and April;
 24 feet deep, in December and June;

and at less than 100 feet (say 90 feet), the variations of summer and winter become wholly insensible. At Yakutsk, in Siberia, the soil remains frozen to a depth of 700 feet all the year round. In Java, under the equator, the line of invariable temperature occurs at a depth of 2 or 3 feet. But these results are subject to important local variations, owing to the different thermal conductivities of the rocks below the surface. It has been ascertained that the lightest and most porous rocks are the best conductors of heat, while those most dense offer the least resistance to its transmission. Cannel-coal is 13 times as resistant as quartz to the passage of heat.

18. Respecting the *heat of the interior*, we see it abundantly manifested in volcanoes, hot springs, borings, mines, and the like. *Volcanoes* are orifices in the crust of the globe, through which are vomited up from below steam, hot ashes, and vast masses of melted rocks. They are abundantly distributed over the earth surface of the present, and there is probably no single region where they have not at one time existed. *Hot springs* throw up large quantities of heated water. They occur more or less in all regions, both near to and remote from volcanoes. Like volcanoes, their occurrence appears inexplicable, except upon the supposition of the prevalence of intense heat in the interior of the globe.

Striking proofs of the universal prevalence of this internal heat is afforded us by the rapid downward increment of heat found in borings, wells, mines, and similar artificial excavations, and we have by direct experiment been enabled to arrive at some important facts relative to its descending rate of increase. Thus it has been found by experiments in coal-pits, Artesian wells, and metalliferous mines, that, after passing the depth zone of invariable temperature, or that at which the surface-heat becomes inappreciable, the temperature begins to rise, and this gradually, but unsteadily, for every fathom of subsequent descent. Reckoning this "zone or stratum of invariable temperature" at from 60 to 90 feet below the surface, according to the nature of the soils and rocks passed through, a rise of 1 degree of Fahrenheit usually takes place for every 60 feet of further descent; and calculating at this rate of increase, a temperature (2400° Fahr.) would be reached, at a depth of 25 miles or thereby, sufficient to keep in fusion such rocks as basalt, greenstone, and porphyry. At the same rate of increase, or even admitting that the thermometer only rises 1 degree for every 90 feet of descent, we would, at the depth of 150 miles or thereby, arrive at such a temperature that even the most refractory rock-substances would be melted. These facts have led some to argue that the highly-heated interior of the globe is in a state of perfect fusion, and is surrounded on all sides by a comparatively thin film of solid, as the liquid interior of an egg is surrounded by its thin stony shell. This theory was long a favourite one among geologists, and the term "crust" is still employed as a convenient term for the rocky exterior of our planet. But the hypothesis of a liquid interior has been opposed by several eminent physicists—notably by Professor Hopkins of Cambridge and Sir William Thomson of Glasgow, who contend that the globe is solid to its centre, with the doubtful exception of occasional vesicular spaces. By the Rev. O. Fisher and others it is believed that a thin zone of liquid-matter occurs between the solid interior and the equally solid superficial crust. When we recollect that pressure has the effect of raising the melting-point of those substances of which the generality of rocks are composed, and that the pressure due to gravitation must be excessive at great depths within our globe, we see that it is not improbable that, notwithstanding the extraordinary internal heat, the earth may be practically solid to its centre; its heated materials being retained in the solid state as a rule by the enormous pressure, but becoming liquefied and forcing their way to the centre where the pressure is locally relieved. Intense as the interior heat may be, and active as it undoubtedly is in the production of volcanic

phenomena, the surface temperature of the globe is scarcely, if at all, affected by it (according to Fourier, only $\frac{1}{17}$ th of a degree), owing to the weak conducting properties of the rocky crust.

19. Besides these original conditions of form, size, motions, density, and temperature, there is also that of its atmosphere, or aerial envelope that surrounds it on every side, and becomes an integral and indispensable portion of its constitution. This atmosphere, as is well known, is mainly composed of two gases, nitrogen and oxygen—79 parts of the former to 21 of the latter—with a small percentage of carbonic acid and other extraneous impurities. As at present constituted, the air is indispensable to the life of vegetables and animals. Both alike breathe it, and by this breathing the functions of vitality in both are alike sustained. But while it is inhaled by both, animals absorb oxygen and emit carbonic acid; while carbonic acid is decomposed by plants, which in turn retain the carbon, and set free the oxygen, and thus the equilibrium or balance is restored and perpetuated. Being an elastic or compressible medium, the air nearest the sea-level is denser than that at considerable elevations; and by calculating the rate at which this rarity takes place, it has been estimated that, at the height of 45 miles above the sea, the atmosphere becomes so rare as to be all but inappreciable. We have thus, surrounding the earth, and partaking in all its movements, a gaseous envelope or atmosphere, whose pressure at the sea-level is estimated at $14\frac{3}{4}$ lb. avoirdupois on every square inch of surface, but which gradually becomes lighter and lighter, or more attenuated, as we ascend, till, at the height of 45 or 50 miles, its presence is inappreciable. The weight of the atmosphere is generally estimated as equal to the weight of a column of mercury 30 inches in height, or to one of water 34 feet in height; and as there are 14.7304 lb. avoirdupois on the square inch, the reader can easily imagine the enormous pressure exerted on the almost innumerable square inches of the earth's surface by this thin elastic medium, which is usually regarded as the type of lightness and rarity. Through this envelope (further details of which are given in Chap. XI.) the heat of the sun is diffused and modified; it is also the recipient and diffuser of all watery vapours arising from the earth; and from local alterations in its density or expansibility, caused by heat and the like, arise all aerial currents or winds, whether regular and steady, or irregular and fitful. The atmosphere is thus the grand medium through which heat, moisture, and other vital influences are communicated to the plants and animals that reside upon the earth's surface; it is also the great laboratory in which all meteorological and electrical

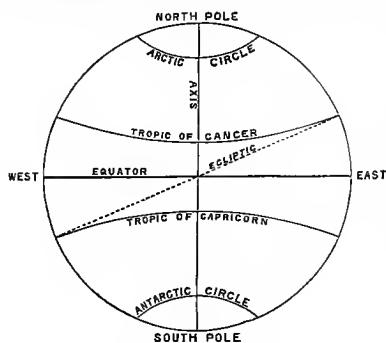
phenomena are elaborated ; and hence all the varied aspects and results of winds, clouds, rains, snow, hail, thunderstorms, and the like, that constitute the essentials of climatic diversity.

Technical Subdivisions—Points, Circles, Zones, &c.

20. In treating of the earth thus constituted and surrounded, geographers make use of certain terms and technicalities expressive of distance, position, and the like, on its surface, and with these it will be necessary for the student, at this stage, to render himself familiar. Thus, the direction from which the earth moves in its daily rotation is called the *West*; that towards which it moves, the *East*; the point to which a spectator looks, with the east on his right hand, and the west on his left, is called the *North*; and that behind him the *South*. In this rotation from west to east, any point on the earth's surface turns towards the sun in the morning, and away from him after mid-day; and thus the terms *Sunrise* and *Sunset* (the sun being a stationary centre) express not real, but merely apparent phenomena. The imaginary line on which the earth rotates is termed its *Axis*, and the terminations of this axis its *Poles*—that towards the north being known as the *North Pole*, and that towards the south as the *South Pole*. From an idea of the early geographers, who were inhabitants of the northern hemisphere, that the north pole was uppermost (though in reality there can be neither upper nor under in a globe freely rotating in space), it is customary in our maps and charts to place the northern part at the top, and the southern at the bottom, with the east on the right hand and the west on the left. A line distant alike from either pole, and dividing the earth into two equal portions (Lat. *æquus*, equal), is called the *Equator*; the northern half being known as the *Northern Hemisphere*, and the southern as the *Southern Hemisphere*. In the same way we may speak of the *Eastern Hemisphere* and *Western Hemisphere*, by supposing the globe divided by a line passing through the poles, and thus necessarily cutting the equator at right angles. Reckoning London as a fixed point on such a line, Europe, Asia, and Africa will lie in the eastern hemisphere, and North and South America in the western.

21. Like other circles, the circumference of the earth is divisible into 360 equal parts or *degrees*, and in this case each degree will equal about 69.05 British statute miles. At the distance of $23\frac{1}{2}$ degrees north and south of the equator, as shown in the accompanying diagram, are two parallel lines called the *Tropics* (Gr. *trope*, a turning), from their marking the turning-points of the

sun in the ecliptic; that on the north being known as the *Tropic of Cancer*, and that on the south as the *Tropic of Capricorn*,



Zones and Circles.

because these constellations occupy a corresponding part in the heavens. At the same distance ($23\frac{1}{2}$ degrees) from either pole is a parallel line—that on the north being called the *Arctic Circle* (from the northern constellation, *Arctos*, the Bear), and that on the south the *Antarctic Circle*, because opposite (*anti*, opposite) to that of the

north. The space or belt between the tropics is called the *Torrid Zone*, because the sun, being always vertical in some part of that space, produces a greater degree of heat than in regions where his rays strike more obliquely. The spaces between the tropics and the Arctic and Antarctic Circles, on either side, are termed the *Temperate Zones* (north and south); and those between these circles and their respective poles the *Frigid Zones*. The breadth of each of the torrid zones is therefore about $1622\frac{1}{2}$ statute miles;¹ of each of the temperate, about 2969; and of each of the frigid, $1622\frac{1}{2}$ miles. Or, calculating their areas in square miles, the earth's superficies is made up nearly as follows:—

North Frigid Zone, . . .	8,132,797 square miles.
North Temperate Zone, . . .	51,041,592 "
Torrid Zone, . . .	78,314,115 "
South Temperate Zone, . . .	51,041,592 "
South Frigid Zone, . . .	8,132,797 "

It is customary for the botanist and zoologist to subdivide those zones more minutely into equatorial, tropical, sub-tropical, warm-temperate, cold-temperate, sub-arctic, arctic, and polar; but we shall notice these subdivisions and their characters when we come to treat of the distribution of vegetable and animal life.

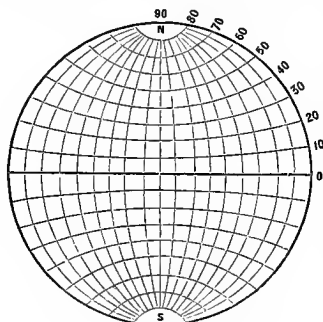
22. The equator has been already described as a circle midway between the poles, and cutting the globe into two equal portions. A line which cuts the equator obliquely, and touching the tropics, is called the *Ecliptic* (Gr. *ekleipsis*, an eclipse). The ecliptic of

¹ The length of a British statute mile is 1760 yards, or 5280 feet; while a geographical mile is 2028.92 yards, or 6086.76 feet.

the heavens is the great circle described for the sun in his apparent annual journey round the earth, and is so named from the circumstance that eclipses can happen only when the moon is in the plane of this circle, or very near it. The points where the ecliptic cuts the celestial equator are called the *Equinoctial Points* or *Nodes* (Lat. *æquus*, equal; *nox*, *noctis*, night), because when the sun is in these parts of his course, the day and night are of equal duration. These equinoxes take place twice a-year—namely, on the 21st March and 21st September. The ecliptic drawn upon our terrestrial globes and maps of the world merely indicates the angle which the plane of the celestial ecliptic makes with the earth's equator. The term *Greater Circles* is sometimes applied to the equator and ecliptic, because they encircle the earth at the thickest part, or in planes that pass through its centre; and that of *Lesser Circles* to the tropics, arctic and antarctic circles above described. Besides these circles, another set of lines, drawn from pole to pole over the earth's surface, and cutting the equator at right angles, are termed *Meridians* (Lat. *meridies*, mid-day), because when any one of these lines is opposite the sun it is mid-day, or twelve o'clock, at all the places situated along that meridian on the same side of the globe, while on the opposite side it is midnight. When it is noon, for instance, in any particular part of Britain, it is midnight at an opposite and corresponding point near New Zealand, and so on for the intermediate hours at directly opposite parts along the same meridian. Diametrically opposite points on the globe are said to be the *Antipodes* of each other (Gr. *anti*, opposite, and *pous*, *podos*, foot), because the feet of their respective inhabitants are placed, as it were, in opposition to each other. A point in the sphere of the heavens vertically over a spectator's head is the *Zenith*, while one in the same sphere vertically under his feet is the *Nadir*. These points are the *Poles* of the visible horizon, and are, of course, 90 degrees distant from every part of it.

23. The position of a place on the earth's surface is determined by what is termed its *Latitude* and *Longitude*. The latitude of a place is its distance north or south from the equator; hence we speak of north latitude (N. Lat.) in the northern hemisphere, and of south latitude (S. Lat.) in the southern hemisphere. Longitude, on the other hand, is measured east and west of any fixed meridian—different countries adopting different meridians (usually that of their capitals), and Britain that of the Royal Observatory at Greenwich; hence English geographers speak of east longitude (E. Long.) and west longitude (W. Long.), according as a place may be situated eastward or westward of the meridian of Green-

wich. The terms *longitude* and *latitude* arose from a notion of the ancients that the earth was longer from east to west than from north to south; in other words, that it had *length* (longitudo) and *breadth* (latitudo)—an idea which is thereby most conveniently expressed. The circles on the earth being divided into 360 degrees, and each degree again into 60 minutes, each minute into 60 seconds, and so on, the position of a place can be indicated with great precision; and for the sake of brevity certain signs are employed, as $4^{\circ} 6' 12''$, meaning thereby 4 degrees, 6 minutes, and 12 seconds. The distance between the equator and either pole being only the fourth part of the earth's circumference, the latitude of a place north or south of the equator can never exceed the fourth part of 360, or 90 degrees. Longitude, on the other hand, being measured east and west of a fixed meridian, embraces a



Parallels and Meridians.

whole hemisphere, or 180 degrees; and as the meridians all converge towards the poles, the size of degrees of longitude becomes less and less as we approach these extremities. The lines of latitude being necessarily parallel to each other, geographers speak of *parallels of latitude*, designating those that lie near to the equator as *low* latitudes, those that approach the poles as *high* latitudes, and those that intervene as *middle* latitudes.

[It has been stated above that the value of a degree of longitude varies according to the latitude, being equal to a degree of latitude at the equator, but gradually becoming less as we approach the poles. The following table exhibits this diminution for every 5 degrees of latitude both in geographical and British statute miles:—

Degree of Latitude.	Geographical Miles.	English Miles.	Degree of Latitude.	Geographical Miles.	English Miles.
0	60.00	69.07	50	38.57	44.35
5	59.77	68.81	55	34.41	39.58
10	59.09	67.95	60	30.00	34.50
15	57.95	66.65	65	25.36	29.15
20	56.38	64.84	70	20.52	23.60
25	54.38	62.53	75	15.53	17.86
30	51.96	59.75	80	10.42	11.98
35	49.15	56.51	85	5.23	6.00
40	45.96	52.85	90	0.00	0.00
45	42.43	48.78			

NOTE, RECAPITULATORY AND EXPLANATORY.

In the foregoing chapter we have noticed those primary conditions of form, motion, size, density, temperature, and the like, which belong to the earth as a member of the solar system. These conditions lie, as it were, at the foundation of all change and diversity on the earth's surface—day and night, heat and cold, summer and winter, meteorological fluctuation and climate, oceanic tides and currents, geological waste and reconstruction, and, in fine, all that confers diversity on land and water, and consequently on vegetable and animal life, being directly or remotely dependent on the original constitution of the globe, and its connection with the solar system. It is necessary, then, that the student should render himself familiar with the *planetary relations* of the earth—its spheroidal form, its daily rotation and annual revolution, its density, temperature, magnitude, and admeasurements, as well as with those terms and technicalities by which its several portions and positions are known and described. As an *oblate spheroid*, then, the earth has an equatorial diameter of 7925.648, and a polar diameter of 7899.170 miles (or, according to the mean of measured meridional arcs, 7926.05, and 7899.6); rotates on its own axis in 23 hours, 56 minutes, and 4 seconds, or in one *day*; revolves round the sun in an elliptical path or orbit in 365 days, 6 hours, 9 minutes, and 10 seconds, or one *year*; and is in turn attended by the moon, which performs her revolution in 27 days, 8 hours, or one lunar *month*. As the mean circumference of the earth is 24,858 miles, and as she rotates on her axis once in 24 hours, it is clear that any spot on the equator must be borne round at the rate of more than 1000 miles an hour. With every successive removal from the equator, however, the *circles of latitude* become smaller and smaller, and as they are all carried round within the same period of 24 hours, their rate of motion must be proportionally less. At the 60th parallel, for example, this motion is only 500 miles an hour, and at the absolute poles it ceases to exist. The mean *density* of the rocks known at the surface of the earth is about $2\frac{1}{2}$ times that of water, while that of the entire mass is $5\frac{1}{2}$. The earth's own proper temperature, as distinct from that received by its atmosphere and surface from the sun, increases according to the depth, and this increasing temperature is apparently the cause of volcanoes, hot springs, and other thermal phenomena. Of the earth's interior we know little, except that the materials of which it is composed are intensely heated, and are subjected to enormous pressure. It is supposed

that these heated materials are retained generally in the solid state by the excessive pressure, but where this is locally relieved they become liquefied, and force their way to the surface in volcanic regions. Rocks being bad conductors of heat, the surface temperature, it is calculated, cannot be affected by the internal heat beyond the merest fraction of a degree. The earth is surrounded by an aerial envelope or atmosphere, consisting in the main of 79 parts nitrogen and 21 oxygen, with a fractional percentage of carbonic acid; and this gaseous envelope, being an elastic medium, is densest at the earth's surface (where it presses with a weight of $14\frac{3}{4}$ lb. on the square inch), and becomes rarer and rarer as we ascend in space, till at the height of 45 or 50 miles its presence becomes inappreciable. This atmosphere is the medium through which the sun's light and heat are equally diffused; the laboratory in which all meteorological phenomena,—winds, rains, clouds, storms, &c.—are elaborated; and, in fine, the source whose varied mutations are the proximate causes of all climatic diversity. In treating of the earth, various terms and technicalities are necessarily employed by geographers, and with these the student should early render himself familiar. Thus, the imaginary line on which the earth turns in her daily rotation from west to east is termed the *axis*; the extremities of this axis, north and south, the *poles*; the *equator*, the circle between the two poles which cuts the globe into two equal portions or *hemispheres*; the *torrid, temperate, and frigid zones*, the varying belts of surface temperature as we proceed northward and southward from the equator, where the sun's heat is greatest; the *ecliptic*, indicating the apparent path of the sun round the earth; *meridians*, those lines drawn from pole to pole over the earth's surface, and at right angles to the equator, along which the sun is vertical at his highest daily ascension or *noon*; *latitude*, the distance of any place, measured in degrees, north or south of the equator; and *longitude*, the distance of the same place east or west from any arbitrary or convenient meridian—that in Britain being the meridian of Greenwich; that in France, Paris; and that in Germany, the Faroe Islands.

To the student who wishes to enter more minutely into the consideration of the earth's planetary or astronomical relations, we may recommend perusal of Lockyer's 'Elementary Lessons in Astronomy' and Sir J. Herschel's 'Outlines of Astronomy.' For a fuller explanation of the technical terms of his science, he may consult the *Glossary* appended to the present volume.

III.

THE EARTH—ITS INDIVIDUAL STRUCTURE AND COMPOSITION.

The Rocky Crust—Its Constitution and Formation.

24. HAVING considered in the preceding chapter some of the more obvious relations of the globe as a member of the solar system, and the terms usually employed to express these connections, we now proceed to describe the leading features of its own special structure. As the knowledge of its general relations was derived chiefly from Astronomy, so a knowledge of its individual structure is mainly obtained from the teachings of Geology. As the one set of facts could be taught without going deeply into the problems of the astronomer, so the other may be understood without entering largely into the reasonings of the geologist. What, for instance, is the nature of the earth's rocky crust? How are its rocks arranged, and how does this arrangement affect its superficial character? What has stretched out the level plain and upheaved the rugged mountain? What renders one soil ungenerous and sterile, and another genial and fertile? And as the earth's crust is continually undergoing modification under the operations of external and internal forces, what the effects of such modifications on the general geography of the globe? These and similar problems geology endeavours to solve, and, with a little explanation, these solutions may be rendered intelligible to the student of Physical Geography.

25. Geologists speak of the "crust of the globe" just as the housewife talks of the "crust of her loaf." The crust of the loaf is one thing, the inside of it another. The crust or exterior portion of the earth, composed of rocks and rock materials that can be seen and handled, is one thing; the interior, of which we can know nothing by direct observation, may be, and in all likelihood is, a very different thing. By observation and comparison we can determine a great many truths respecting the structure and

composition of the former ; respecting the latter we can offer at best little more than conjecture. This outer portion or rocky crust is the great theatre of all geographical phenomena—the foundation of the land and waters—the arena of climatic influences—the field of vital development ; and, as such, it behoves the geographer to know something of its history and constitution. That history, as geology has taught us, is a long and varied one ; that constitution, as bearing more immediately upon the problems of geography, we shall endeavour briefly to explain.

26. On the most cursory inspection of quarries, railway-cuttings, sea-cliffs, and ravines, the observer will find a great portion of the rocks arranged in layers, or lying one above another in beds or strata (Lat. *stratum*, spread out). These are said to be *stratified*, and generally consist of sandstones, clays, shales, or consolidated muds, limestones, and other similar rocks. He will also find another set not spread out in layers, but rising, hard and massive, in no determinate arrangement. These are termed the *unstratified*, and consist of such rocks as the granites, greenstones, basalts, and lavas. How, he will naturally inquire, have two sets of rocks so dissimilar in character and arrangement been produced ? And as we can only interpret nature's productions by a knowledge of nature's operations, we must seek for the answer to this question in what is now taking place around us. And first, if we turn to any lake, estuary, or bay of the ocean, we will find that the mud, sand, and gravel carried down by the rivers or washed from the cliffs by the waves and tides, are deposited and arranged along the bottom of these receptacles in layers or strata more or less horizontal, and in course of ages one above another, precisely like the shales and sandstones of the quarries and sea-cliffs. Here, then, we are entitled to infer that rocks arranged in layers or strata have been formed through and by the agency of water (Lat. *aqua*) ; that is, have been deposited as sediment (Lat. *sedere*, to settle down) in water, or brought together and assorted by the action of moving water ; and hence they are termed *aqueous*,



A A A, Stratified ; B B, Unstratified Rocks.

sedimentary, or *stratified*. If we turn, in the next place, to the volcano or burning mountain, we find that lava and other molten rock-matters are discharged from its crater ; and these, when cooled and consolidated age after age, form mountain-masses, and fill up chasms and rents produced by earthquakes, precisely as the

granites and greenstones and basalts do among the stratified rocks with which they are associated. Here, again, we are entitled to infer that the greenstones, basalts, and other similar rocks, are the products of fire (Lat. *ignis*, fire), and hence they are designated *igneous*, *eruptive*, or *unstratified*.

27. In the crust of the earth, then, we have two main sets of rocks—the stratified and the unstratified; the one formed through and by the agency of water, the other through and by the agency of fire. The former are chiefly the products of aqueous and atmospheric waste, the latter the products of igneous reconstruction; and between these two forces, the aqueous and igneous, the crust of the earth has ever been held in habitable equilibrium. Were the aqueous and atmospheric forces to operate uncontrolled, all the higher portions of the dry land would in the course of ages be worn down, and the whole reduced to a dreary uniformity of level; but to prevent such a contingency, the volcanic forces are perpetually exerting themselves from below, and once more upheaving the crust into dry land and diversity of surface. What the frosts and rains and rivers are wearing and carrying from the higher lands is deposited in layers of mud, sand, and gravel in the lakes and estuaries below; and what is wasted from the sea-cliffs by waves and tides is borne along and distributed in the bays and other sheltered recesses of the ocean. These deposits, in course of time, become consolidated, by pressure and internal chemical changes, into shales and sandstones and conglomerates; and we might readily conceive the low, level, superficial aspect of a globe where this sedimentary process had gone on unchecked for ages. But the forces from within are as incessantly at work as the forces from without, and sooner or later (according to some law whose order is yet unknown) these strata are upheaved into dry land, with all that diversity of surface which seems inseparable from the efforts of the earthquake and volcano. The great design of creation seems clearly to be diversity in time as well as diversity in space. Hill and dale, level plain and rugged mountain, are ever attended by diversity of soil, diversity of winds and clouds, heat and cold, and all the other climatic influences on which diversity of plant-life and diversity of animal life are so intimately dependent. To the primary geological oscillations of the earth's crust—its submergences and upheavals, its volcanic outbursts and earthquake convulsions, the wearing away of its softer rocks, and the resistance of its harder—are we therefore indebted for all that confers on its surface geographical variety and diversity. Hence the value of some knowledge of geology to him who would thoroughly comprehend the existing aspects of nature. If some

knowledge of anatomy be essential to the artist who would depict with accuracy the animal frame, equally so is some acquaintance with geology of importance to the geographer who would comprehend aright the mountains and plains, the hills and dales, and all the other aspects of superficial variety which give to our globe at once its endless forms of scenery, and its subtlest modifications of climate and vitality.

Relative Age and Arrangement of Rock-Formations.

28. If, then, the crust of the globe be in a state of oscillation between the aqueous and atmospheric forces that waste and wear from without, and the igneous forces that reconstruct and upheave from within—if cliffs and hills are worn down, and lakes and estuaries filled up and converted into alluvial plains—if plains are thrown up into mountains, and the sea-bed into dry land—if large tracts of the earth are gradually raised higher and higher above the ocean, while other regions are gradually submerged—it is clear that different portions of the rocky crust must be of different ages, and composed of different materials. The present distribution of sea and land has undergone many noted modifications even within the historic era; and if such changes have been accomplished within a period so brief as a few thousand years, what may we believe to have taken place during the thousands of ages that preceded human history? So numerous have been these changes, as clearly demonstrated by geology, that every portion of the existing dry land has been repeatedly beneath the waters; and that which now constitutes the bed of the ocean, has probably been the dry land of former epochs.

“ There rolls the deep where grew the tree;
Oh, Earth, what changes hast thou seen!
There, where the long street roars, has been
The stillness of the central sea.

The hills are shadows and they flow
From form to form, and nothing stands;
They melt like mists, the solid lands—
Like clouds, they shape themselves and go!”

The record of these changes lies in the stratified rocks, each period producing its own sedimentary deposits, and these deposits constituting what geologists term *formations*, as having been formed at certain periods, laid down in certain areas of sea, lake, or estuary, and as bearing some impress of the geographical conditions under which they were collected. Farther, as the sediments

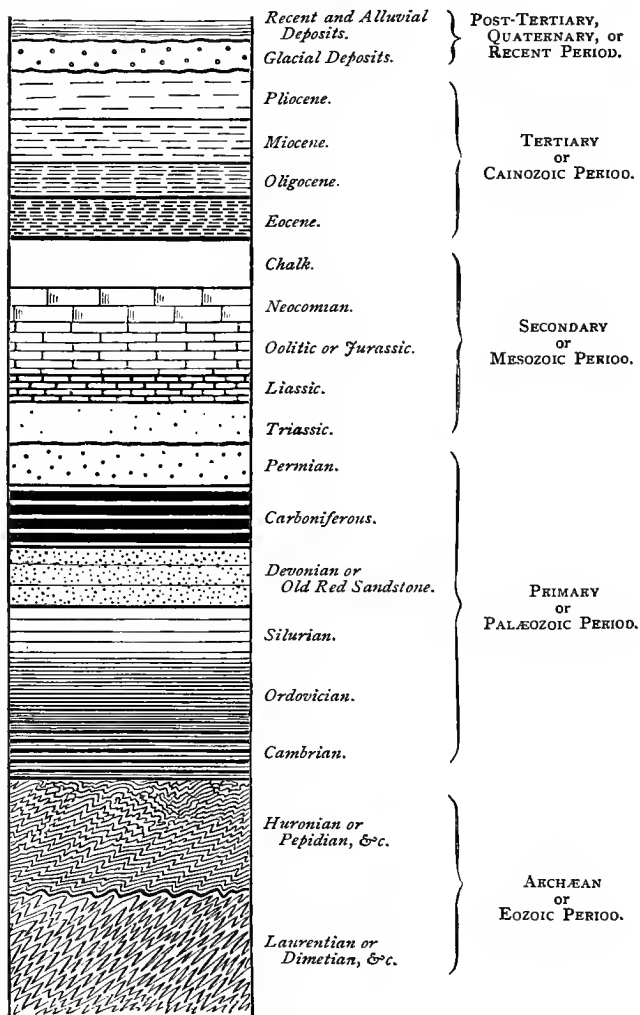
of existing lakes and estuaries and seas imbed the remains of plants and animals that have lived in these areas, or have been drifted from the land—leaves, branches, trunks, bones, teeth, shells, and crusts; so the sediments of former ages contain the remains of plants and animals that then existed—these remains being petrified, or converted into stone. These *petrifications* (Lat. *petra*, stone; *fieri*, to become), or *fossils* (Lat. *fossus*, dug up), as they are termed, differ widely in many instances from the plants and animals now peopling the globe; and this difference may be said to increase with the depth and age of the strata that contain them. As a general rule, the older strata are the deeper seated; the older, harder, and more crystalline lie below the recent and superficial; and the older the strata, the greater is the difference between their fossil plants and animals and the plants and animals now existing. Founding on principles such as these, geologists have arranged the stratified rocks into formations and systems according to their relative antiquities—each division representing (as nearly as can be determined) a different arrangement of sea and land, and a different aspect of vegetable and animal life during the period of its deposition.

29. Thus, beginning at the recent and superficial, which contain few extinct forms of life, and descending through systems whose fossils belong chiefly to extinct races, we have:—

<i>Systems.</i>	<i>Periods.</i>
1. POST-TERTIARY or RECENT ACCUMULATIONS, 2. TERTIARY SYSTEM, or PLIOCENE, MIOCENE, and EOCENE,	CAINOZOIC (Recent Life).
3. CRETACEOUS, or CHALK SYSTEM, 4. JURASSIC, or OOLITIC and LIASSIC SYSTEM, 5. TRIASSIC, or UPPER NEW RED SANDSTONE,	
6. PERMIAN, or LOWER NEW RED SANDSTONE, 7. CARBONIFEROUS SYSTEM, 8. DEVONIAN, or OLD RED SANDSTONE, 9. SILURIAN, or UPPER SILURIAN SYSTEM, 10. ORDOVICIAN, or LOWER SILURIAN SYSTEM, 11. CAMBRIAN SYSTEM,	MESOZOIC (Middle Life).
12. ARCHEAN, PRE-CAMBRIAN, or METAMORPHIC SYSTEMS (LAURENTIAN, &c.),	PALÆOZOIC (Ancient Life).
	Eozoic (Dawn of Life).

Or, arranging them in diagrammatic form, as they occur in the British Islands, we have the intelligible representation that appears on the following page. It is not asserted that these rock-formations and systems occur in full and regular succession in every part of the world, but merely that such is their order in time wherever they have been examined by the geologist. The Old

GENERAL VIEW OF THE STRATIFIED SYSTEMS OF GEOLOGY.



Red Sandstone or the Carboniferous system may occupy the whole surface of a country without any of the newer systems being present, just as the Chalk or Oolite may be the surface rock, without having the whole of the older strata below ; but the oolite never occurs above the chalk, nor the old red sandstone above the coal. The order of their succession is fixed and determinate, and each system represents a portion of time as well as a series of rocks—a portion of time in world-history when certain distributions of sea and land prevailed, and when certain forms of vegetables and animals lived and died, just as certain reigns and dynasties and nationalities represent successive stages in the history of the human race.

30. As the stratified rocks have been arranged in chronological sequence, so also the unstratified or igneous admit of a similar, though less precise, arrangement. As at present, so during every former epoch of the earth's history, the volcanic forces have been in a state of activity—breaking up the stratified crust, throwing out lava and other products in the formation of hills, and filling up earthquake fissures with molten-rock matter from below. In course of the earth's mutations these earlier products become submerged beneath the waters of the ocean, and overlaid by newer sedimentary deposits, again to be broken through by another set of igneous operations, and this consecutively and continuously from the most distant ages up to the present day. As a general rule, the earlier igneous rocks are associated with the earlier stratified deposits, and the older and deeper-seated are more uniform and crystalline in texture than the newer and more superficial. Founding on principles such as these, geologists have roughly arranged the igneous or unstratified rocks in the following chronological order :—

1. VOLCANIC, associated chiefly with Tertiary and Upper Secondary strata.
2. TRAPPEAN, associated chiefly with Secondary and Upper Primary strata.
3. GRANITIC, associated chiefly with Primary and Metamorphic strata.

31. The consideration of these systems and subdivisions forms the special subject of geology ; but as each formation occupies a distinct portion of the earth's crust, consists of different kinds of rocks, and presents different soils and surfaces, the following summary may be of use to the student of geography :—

1st. The *Post-tertiary System* consists in the main of clays, gravels, sands, peat-mosses, marls, coral-reefs, and other superficial accumulations, which are still forming, or which have been formed within a comparatively recent period, in lake-basins, river-valleys,

estuaries, and shallows of the ocean. They imbed, in a subfossil state, the remains of plants and animals still existing, but frequently removed from, or extinct in, certain localities which they once inhabited. In volcanic districts they are associated with recent lavas, scoriæ, and similar products; and, generally speaking, they occupy low-lying tracts, and constitute the surfaces of valleys, plains, and other alluvial expanses. Associated with these superficial accumulations, but for the most part lying beneath them, there occur over the northern hemisphere, down to the 40th parallel of latitude or thereby, thick deposits of clay and gravel imbedding huge water-worn blocks or *boulders*; and as these seem to point to a time when large areas of the northern hemisphere were under ice, or subjected to the drift of icebergs that dropped their burdens of clay, gravel, and boulders on the then submerged surface, this period is generally known as the *Boulder, Northern Drift, or Glacial epoch*, and holds a place intermediate between the Post-tertiary and true Tertiary systems.

2d. The *Tertiary System* consists, in general terms, of clays, gravels, sands, limestones, marls, and lignites or beds of wood-coal; and occupies well-defined areas, as if these at one time had been extensive fresh-water lakes, estuaries, and inland seas. The System is usually separated by geologists into three main groups characterised by the proportion of recent shells which they contain. The oldest division is known as the *Eocene* (from Gr. *eos*, dawn; and *cainos*, recent), because the fossil shells it contains include an extremely small proportion of species known to be living at the present day. The next division is termed the *Miocene* (from Gr. *meion*, less); and the third division, *Pliocene* (Gr. *pleion*, more; and *cainos*, recent). A fourth division is recognised by some geologists, who place what they term the *Oligocene* (Gr. *oligos*, little or few) between the Eocene and Miocene. The fossils imbedded in tertiary strata, though closely allied to existing genera and species, are in many instances extinct (especially the gigantic quadrupeds), and point to conditions of climate and distributions of life very different from those at present prevailing. The igneous rocks associated with them are lavas and basalts, the products of volcanoes, long since extinct, or now but partially active. As a general rule, undulating lowlands may be said to constitute the physical features of tertiary districts—the pampas of Buenos Ayres, and the basins of London, Paris, and Vienna, being typical examples; but the Tertiary rocks are often found upheaved to great heights upon the flanks of mountain-chains, as in the Alps, Pyrenees, and Himalayas.

3d. The *Cretaceous System* (Lat. *creta*, chalk) consists, as its name

implies, of thick beds of chalk or soft marine limestones, associated with sands, sandstones, clays, and in some localities with beds of coal and lignite. The fossils belong almost wholly to extinct species; and even where the chalk beds are wanting, the other strata are so replete with their characteristic marine remains, that there is generally little difficulty in recognising the system. The system falls into two well marked divisions—the upper portion containing the vast masses of soft white limestone, while the lower is mainly composed in Britain of sands and clays. The title of Chalk formation is therefore usually restricted to the Upper Cretaceous, while the Lower Cretaceous is termed the Neocomian System, from the town of Neuchâtel (*Neocomum*) in Switzerland, where its strata are typically developed. The associated igneous rocks are chiefly basalts and greenstones; and the physical features of the system in Britain may be said to be low rounded hills, like those of Kent, Surrey, and Sussex, with dry intermediate depressions, where the chalk and sands prevail, and flat fertile vales, where the rich fossiliferous clays come to the surface.

4th. The *Jurassic System* consists largely of limestones, alternating with calcareous clays and sandstones, bituminous shales, and occasional beds of ironstone and coal. It derives its title from its magnificent development in the Jura Mountains of Europe. As a system, it occurs in many parts of the world, and is characterised by its abundant marine remains, land plants of sub-tropical growth, and especially by the profusion of large nautilus-like shells (*Ammonites*) and gigantic land and water reptiles. The unequal wasting of its harder limestones, and softer clays and shales, confer on its landscape an agreeable succession of easy undulations; and unless where thrown up into higher hills by volcanic forces, this gradual alternation of hill and dale is the characteristic geographical feature of the system, as may be witnessed in that broad belt of inland counties which stretches from Yorkshire on the north-east to Dorset on the south-west of England. In England its strata are classed in two main divisions—the Upper being known as the *Oolitic System*, and the Lower as the *Liassic*. The former derives its name from its peculiar limestones or roestones (Gr. *oon*, egg; *lithos*, stone), which consist in many instances of rounded grains like the roe of a fish.

5th and 6th. The *Triassic* and *Permian Systems*, which were formerly considered as one great formation under the name of the *New Red Sandstone* (because of its position above the coal bearing rocks, in contradistinction to the old red sandstone which lies below the coal), consist in the main of soft reddish sand-

stones, yellowish magnesian limestones, and variegated clays and marls, with occasional deposits of rock-salt and gypsum. The lower portion, being largely developed in Perm in Eastern Russia, has given rise to the term Permian; and the upper, consisting in Germany of three well-marked members—the *Keuper*, *Muschelkalk*, and *Bunter* (sandstones, limestones, and marls), has received the name of Trias, or triple group. The fossil remains of these systems are chiefly marine, with footprints of birds and amphibious reptiles. The physical features of the new red sandstone are by no means decided—the limestones and harder sandstones forming inconspicuous hills and ridges, the softer clays and marls being worn into vales and expanses of a flat, moist, and retentive character, better fitted for pasture than for corn-culture, and of which Cheshire in our own country may be taken as a typical example.

7th. The *Carboniferous System*, so called from its yielding the main supply of coal (Lat. *carbo*, coal) in Europe and America, consists of sandstones, shales, clays, limestones, ironstones, and coals in frequent alternation, as if they had been deposited for ages in seas and estuaries, subjected to repeated subsidences and elevations. Broadly speaking, it may be said that there are three main divisions in the system as it is developed in the typical localities in South Britain—viz., the *Mountain Limestone*, the *Millstone Grit*, and the *Coal Measures*, the last named being the highest in position. The fossils of the system are abundant—marine, estuarine, and terrestrial—the most notable being that excess of vegetable growth that led to the formation of numerous seams of coal. Belonging to the Palæozoic or far-back ages of the world, these remains have but little relationship to existing genera and species, and the highest known forms are merely fishes and reptiles—no bird or quadruped having yet been detected beneath the new red sandstone. With the exception of the trap hills (greenstones, basalts, tufas, &c.) that intersect the system in some localities, and those bold cliffs and scars of limestone (mountain limestone) so characteristic of Yorkshire and Derbyshire scenery, there is little attractive in the physical features of the coal-formation, monotonous moorlands of cold retentive soil (Northumberland, Lanark, Linlithgow) being a common occurrence in the geography of the system. Like all the older systems, however, it is rich in mineral and metallic products—coal, lime, iron, lead, zinc, silver, and antimony being among its most important contributions to modern industry and civilisation.

8th. The system of arenaceous rocks, which immediately underlies the Carboniferous, makes its appearance under two very

distinct types in Britain. In Scotland and the West of England its beds consist of red sandstone, conglomerate, and shale, containing a few fish and plant remains that suggest a *fresh water* origin for the system, and in these areas it is known as the *Old Red Sandstone*. In Devonshire, where it is denominated the *Devonian System*, it consists of sandstones, shales, and limestones containing *marine* fossils in remarkable abundance. Thrown into many irregularities by trap (often felstone) eruptions, the physical features of the old red sandstone are often varied and picturesque, and in general its slopes are dry and of moderate fertility—the larger portions of Devonshire, Hereford, and Forfar being typical areas.

9th. The *Silurian System* (so called from its typical development in South Wales, which was anciently inhabited by the Silures) consists of numerous slaty or hard shaly beds, with sandstones, conglomerates, and intercalated limestones. Its fossils are eminently marine, and consist almost wholly of the lower or invertebrate orders (corals, shell-fish, and crustacea), few fishes being found in its strata, and these only in the upper portions of the system. The physical features of the formation are frequently irregular and mountainous, but, from the softer nature of the rocks, are more rounded and massive, and less abrupt and precipitous, than those of the older strata. Central Wales and Shropshire, and the Southern Highlands of Scotland, from St Abb's Head on the east to Portpatrick on the west, with all their variety of hill, glen, and valley, may be taken as typical areas of Silurian scenery.

10th. The *Ordovician System* (so called from its typical development in North Wales, the home of the ancient tribe of the Ordovices) consists essentially of massive gritstones, flagstones, and shaly and slaty beds, with a few zones and bands of conglomerate and limestone. Its fossils are all marine, consisting chiefly of hydrozoa, and corals, and molluscs, and crustaceans. The system includes many volcanic rocks, and gives origin to some of the finest scenery in Britain—the mountain piles of Snowdon, Cader Idris, Helvellyn, and Skiddaw being composed of Ordovician strata.

11th. The *Cambrian System*, so called from its existence in West Wales (the ancient Cambria), is made up of enormous thicknesses of gray grits, sandy flagstones, and slates. It contains few fossils excepting trilobites, but these are remarkable for their abundance and variety. It occupies but little ground in Britain, and the scenery to which it gives origin is rugged and forbidding.

12th. The strata that lie below the Cambrian system are essentially crystalline in their nature, and are known collectively as the *Pre-Cambrian* or *Archæan* (Gr. *archaios*, primeval) or *Metamorphic* Rocks. They consist of such rocks as gneiss, quartz-rocks, mica-schists, slates, and crystalline marbles. They are supposed by some to have undergone a *metamorphism* (Gr. *meta*, beyond; *morphe*, change), or internal change, by heat pressure, or chemical alteration from ordinary sandstones, shales, and limestones. Their study is attended with great difficulties, and they have as yet yielded only a single fossil, and that an extremely doubtful one—the so-called *Eozoon Canadense* of America. The study of these rocks is still in its infancy. In America two main groups have long been recognised,—the *Laurentian* (from the Laurentide Mountains of Canada), and the *Huronian* (from Lake Huron). In Western Wales, three successive systems are said to occur—the *Dimetian* (from the Dimetæ, an ancient tribe of South-West Wales); the *Arvonian* (from Arvon, the former name of Caernarvonshire); and the *Pebidian* (from Pebidian, a hundred near St Davids). The gneissose rocks of the Western Hebrides are referred by some authorities to the Laurentian; and the crystalline rocks of the Highlands are supposed by others to be also of pre-Cambrian age. The crystalline strata of these metamorphic systems excel all others in the grandeur of the scenery to which they give origin—here sweeping up in ridges of vast extent, there weathering down into splintery peaks and crags, as in the mountain regions of Scandinavia, and the Scottish Highlands, and in the summits of Ben Lawers, Schiehallion, and Ben More.

32. Such are the leading features of the stratified systems, and by such, with a little field practice, they may be readily detected in the various areas they occupy. As with the stratified, so with the unstratified,—each great group has its own physical features; and though perhaps less sharply defined, they are still sufficiently distinct to be recognised in hill and mountain ranges as volcanic, trappean, and granitic :—

1st. The *Volcanic*, as already stated, are associated with the more recent formations, and consist of trachytes, basaltic lavas, vesicular lavas, scoriæ, and other similar products—loose and less consolidated in the more recent and active, and harder and more compact in the older and extinct volcanoes. They rise up in dry rocky hills, more or less conical and crateriform; and these are sometimes grouped round some common centre, and sometimes arranged in linear or axial directions. The cones of Vesuvius and Etna, and the crateriform hills of Auvergne, are familiar and well-known examples.

2d. The *Trappean*, so called from the terraciform aspect of many of the hills they compose (Swedish, *trappa*, a stair), consist of greenstones or whinstones, basalts, felstones, porphyries, tufas, and other kindred rocks, and are generally associated with the secondary and upper primary strata. They are ancient volcanic rocks, preserved in hill-ranges more or less persistent, and from their higher antiquity and longer subjection to wasting influences, are now worn into rounded heights, exposed crags, slopes, and terraces, which confer on the landscape a beauty and diversity peculiarly their own—the harder greenstones and basalts standing out on the crags and terraces, while the softer tufas and ashes have been worn down into gentle slopes and declivities. Their soils being dry and genial, the trap hills of a country are generally possessed of great amenity and fertility, and constitute, perhaps, the most valuable agricultural portions of the district in which they occur.

3d. The *Granitic, Plutonic*, or oldest or deepest series of igneous rocks, consists of granites, syenites, porphyries, and the like, which, from their more ancient or deep-seated relations, are generally hard and crystalline in texture and massive in structure. They are of frequent occurrence in the central parts of all the higher and older mountain-chains—being often surrounded by the splintery peaks and abrupt ridges of the metamorphic schists, but presenting of themselves broad massive shoulders of cold sterile moorland and unprofitable heath. Vesuvius, Etna, and the hills of Auvergne, may be taken as typical examples of the Volcanic group of Igneous rocks; the Ochils, Sidlaws, and Arenigs of the Trappean; and the Grampians, Wicklow, and Cornish Mountains of the Granitic.

Connection between Geology and Physical Geography.

33. Understanding the nature of the preceding subdivisions, the student will be able to attach some intelligible idea to such phrases as the river “cutting its way through secondary strata;” “lying in an irregular tertiary basin;” “crossing a plateau of triassic sandstones;” “a cold retentive soil derived from the subjacent carboniferous rocks;” “intersected by a low range of trap hills, whose grassy slopes and terraces;” “bounded by sterile granitic ridges, whose snow-clad summits;” and hundreds of others that are of continual occurrence in geographical descriptions. He will still more fully perceive the intimate connection of geology with his own immediate science when he reflects that

many of the soils which give character and colouring to vegetable growth are derived directly from the disintegration of the subjacent rocks, and are further affected in their fertility by the porous or retentive nature of the beds on which they rest. The soil derived from the Chalk, for instance, is light and absorbent—hence the short sweet herbage of the “downs” of the south of England ; that derived from the clays of the Oolite is stiff, retentive, and less fitted for tillage than for pasture ; the disintegration of trap rocks, rich in soda, potash, and lime, yields a fertile, genial soil, which their structural fissures ever keep dry and pulverulent ; while the scanty disintegration of an impervious granite is poor, cold, and barren. We have seen, moreover, that every geological formation is less or more characterised by its own physical or geographical features. The soft rounded outlines of a chalk range are altogether distinct from the slopes, terraces, and conical heights of secondary trap hills ; while these, on the other hand, are widely different, both in outline and in vegetable covering, from broad-shouldered mountains of granite or the splintery peaks of metamorphic strata. In fine, these formations and rock-groups constitute the framework on which the geographical features are moulded ; and their inherent characters, as subject to external and internal change, have produced, and are ever producing, new varieties of superficial aspect or scenery. Every hill that volcanic energy raises above the general surface, every inequality produced by earthquake convulsion, every glen eroded by river-action, every plain formed by the deposition of alluvial silt, and every inch that one region is elevated above the ocean, or that another may subside beneath it, disturbs the existing geographical equilibrium, confers new features on the landscape, and modifies the habitats of vegetable and animal existence. Geology and geography are inseparably connected ; and thus it is that some acquaintance with the nature and sequence of the rock-formations that constitute the solid crust, and with the causes that produce them, becomes so indispensable to the student of physical geography.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter we have directed attention to the rocky structure of the globe as that which gives colour and character to all external phenomena, and is therefore of paramount importance to the student of physical geography. We have spoken of the “crust,” composed of materials that can be seen

and investigated, as distinct from the "interior," of which nothing can be known by direct observation. This crust, composed of stratified and unstratified, or of water-formed and fire-formed rocks, is held in habitable equilibrium between the disintegrating forces of water from without, and the reconstructing forces of fire from within. To these two opposing powers are chiefly owing the continuous geological modifications of the earth's crust—each modification representing a period during which certain rocks were formed, and the remains of plants and animals that then lived entombed in them in greater or less perfection. These formations being arranged by the geologists in chronological sequence, and each varying in mineral character, and consequently conferring on the landscape different aspects, it is of importance in physical geography to know the order of this arrangement, and the nature of these distinctions. These *formations*, we stated, have been arranged into certain *systems*, and these systems again grouped into certain *periods*, according to the leading features of their fossils, thus :—

1. Post-Tertiary.	}	CAINOZOIC.
2. Tertiary.		
3. Cretaceous.	}	MESOZOIC.
4. Jurassic.		
5. Triassic.		
6. Permian.	}	PALÆOZOIC.
7. Carboniferous.		
8. Devonian.		
9. Silurian.		
10. Ordovician.		
11. Cambrian.		
12. Metamorphic.	...	EZOIC.

As with the stratified systems, so with the unstratified—their arrangement into *Volcanic*, *Trappean*, and *Granitic*, expressing roughly the relative antiquities and nature of the great igneous groups that give character and individuality to the hills and mountain-ranges of the globe. So far, then, as diversity of surface, fertility of soil, character of landscape, and similar peculiarities, are concerned, the connection between physical geography and geology is intimate and inseparable ; and hence the necessity that the student of the one should be less or more acquainted with the leading facts of the other. It by no means follows, however, that the student of geography should be deeply read in the theoretical problems of geology. An acquaintance with its general principles, and the causes that are incessantly productive of new modifications of the earth's crust, the leading formations that compose that crust, the nature of their rocks, and the character

which these impart to the soil and landscape, is all, or nearly all, that he requires. This information he can readily obtain from such manuals of the science as the Author's Introductory and Advanced Text-Books, Sir Charles Lyell's 'Student's Elements of Geology,' and the manuals of Jukes, Geikie, Philipps, or Green, should he wish to extend his information beyond the outline sketched in the foregoing chapter. He must ever bear in mind, however, that the existing geographical aspects of our globe are not the effects of the forces of one epoch, or of several epochs, but the resultants of all the forces to which the crust has been subjected throughout the whole of Geological time—each succeeding epoch obliterating so much of the former, but never wholly effacing all traces of its operations.

IV.

DISTRIBUTION OF LAND AND WATER.

Their Relative Positions and Areas.

34. HAVING noticed the general conditions of the earth as a member of the solar system, and having also adverted to the structure of its own rocky crust as the groundwork of all geographical diversity, we now proceed to consider the more intimate relations of its surface, as composed of Land and Water. When we speak of the earth's surface as composed of land and water, we mean that all the more elevated portions of the crust stand out as dry land, while the lower and more depressed are covered by the waters of the ocean. Geologically speaking, the relations of land and water are continually, though slowly, undergoing change and modification ; geographically speaking, we have to consider what are the respective areas of land and water, their positions on the earth's surface, their actions and reactions on each other, in consequence of their different extents, positions, capacities for heat, &c., and what the influence of these reactions on currents, winds, rains, and all those kindred phenomena that constitute climatic diversity. The present distribution of land and water tends to the production of certain physical and vital results, and the explication of these results forms the sum and substance of our science. No portion of the present distribution could be altered either in its position, extent, or configuration, without being accompanied by a modification of these results, so intimately is the one element bound up with the other in the production of a definite and harmonious whole.

35. As formerly stated, the superficial area of the globe has been computed at 197,000,000 square miles. Of this amount about 51,500,000 consists of dry land, and about 145,500,000 of water ; or reckoning the whole surface of the globe as equal to

1000 parts, 262 of these parts will consist of land and 738 of water. The proportion of land to that of water is therefore as 3 to 8, or nearly as *one to three*; or, expressing it fractionally, while *one-fourth* of the earth's surface is composed of dry land, the other *three-fourths* are covered by the waters of the ocean. Considered in hemispheres, northern and southern, the proportions of land and water are nearly as follow :—

Northern Hemisphere,	Land,	38,000,000	square miles.
Do.	do.	Water,	60,500,000 „
Southern Hemisphere,	Land,	13,500,000	„
Do.	do.	Water,	85,000,000 „

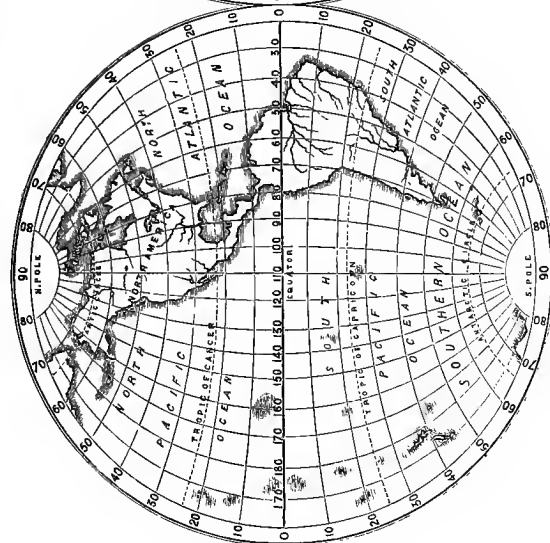
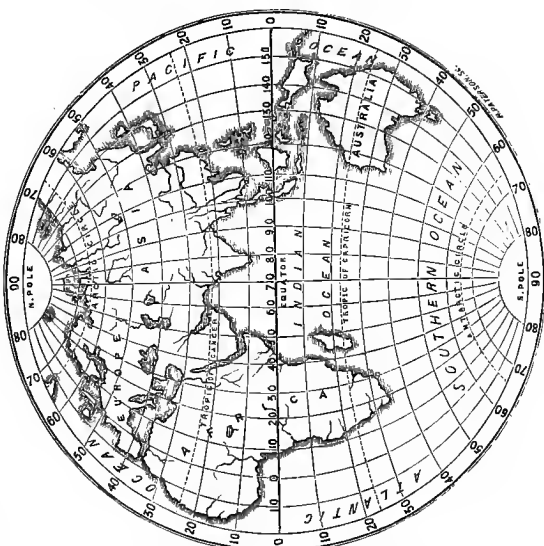
There is thus about three times as much land in the northern as there is in the southern hemisphere; and if we make the estimate in eastern and western hemispheres (20° W. long. to 160° E. long.), there are about 37 millions square miles of land in the former, while there are only 14½ millions in the latter. As to the distribution of land and water in the different zones, it may be stated, in very general terms, that the land forms about *one-third* of the north frigid zone; *one-half* of the north temperate zone; *one-half* of the torrid zone; *one-tenth* of the south temperate zone—the amount in the south frigid zone being at present unknown. The *mean elevation* above the sea-level of all the land on the globe—*islands as well as continents, mountains as well as plains*—is estimated by Humboldt at somewhat less than 1000 feet. The *mean depth* of the ocean, as deduced from recent soundings, is at least 15,000 feet. Hence it has been calculated that the cubic contents of the ocean is about 40 times that of the solid land. Were the mass of the present land spread out equally upon the ocean floor, it would elevate it only 375 feet above its present level. Had the earth's surface been perfectly spherical, it would be everywhere buried beneath an ocean nearly two miles deep. The present arrangement of sea and land—the mean depth of the one, and mean altitude of the other—are attended with most important results, physical and vital,—*physical*, in all that relates to winds, rainfall, temperature, climate; *vital*, as regards the distribution of plants and animals, and the features and habits they are compelled to assume.

36. The boundaries of this terraqueous arrangement (Lat. *terra*, land; *aqua*, water) are extremely irregular. Here the land spreads out in broad unbroken masses, there the waters stretch away in vast continuous expanses; here the land rises up in mere specks and fragments, there the water inserts itself among them in areas equally limited and irregular. Here the land juts boldly out into the ocean in *capes* and *promontories*, there the ocean runs sharply

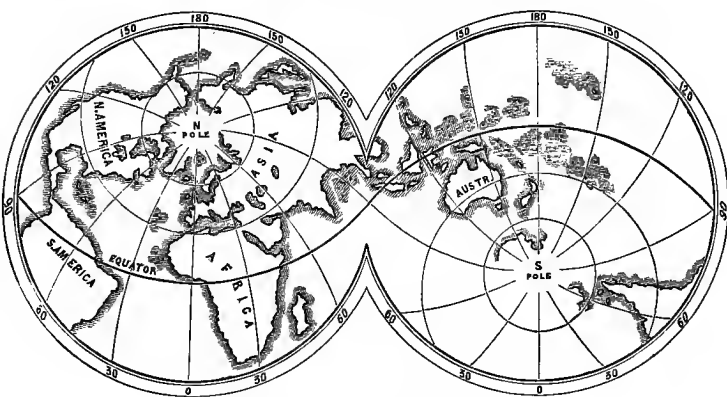
into the land in *bays* and *gulfs*; here the land trends uninterruptedly for leagues, there the ocean embays itself with gentle curves into the bosom of the land. Although this distribution seems to obey no regular order, and has been continually changing throughout all geological time, yet we may rest assured—and not the less assured because we are unable to discover it—that there is a law governing the insensibly varying relations of sea and land, a power protecting the barriers of the one, and defining the “hither shalt thou come, but no farther,” of the other. This boundary between the land and water is known as the *shore-line* or *coast-line*—the former having more especial reference to the margin washed by the waves, the latter to the terrestrial verge that opposes the ocean. The space alternately covered and laid bare by the tides is termed the *beach* or *strand*; and the fringe of land bordering on, and more or less influenced by, its proximity to the sea, is spoken of as the *seaboard* of a country or continent. This sea-belt is generally marked by the peculiarity of its plants and animals, as well as by the character of its inhabitants—these differing in many points from those of the interior or inland districts. In like manner, on the configuration of the shore-line depends much that relates to the climate as well as to the industry and commerce of a country. A regular and unbroken coast is generally an exposed and ungenial one, and one unfavourable to maritime enterprise; while one indented with gulfs and creeks and bays has more of genial diversity, and is better fitted for the purposes of navigation and commerce. As a general rule, the greater the number of miles of coast-line in proportion to the size of a country, the more valuable is that country for the requirements of industry and enterprise; and one has only to glance at the shore-lines of Europe, as compared with those of Africa or South America, to be convinced of this reality. Europe has 143 square miles of surface to every geographical mile of coast-line; Asia 469; Africa 895; N. America 265; S. America 434; and Australia 432. The actions and reactions of the physical world are not more marked and certain than the influence of the physical on the intellectual and industrial; and but for the establishment of such deductions, geography would be shorn of half its interest and instruction.

37. A glance at the Map of the World will show that the land-masses are situated chiefly in the northern hemisphere—there being about three times as much land in the northern as there is in the southern hemisphere. And if we look at the distribution of this land as regards the zones of temperature, we will find that the greatest proportion is situated in the north temperate zone, or

THE WORLD.

Western Hemisphere.*Eastern Hemisphere.*

in that which contains all the better portions of Europe, Asia, and North America ; while only comparatively narrow or isolated tracts are cut directly by the equator or central torrid line. Another glance at the map will show that while the land lies in broad unbroken masses towards the north, it stretches towards the south in curious gradually tapering projections. Again, if we suppose the globe to be divided into hemispheres by the plane of the horizon of London (the dividing line being 90° all round from London), we will find that nearly all the land lies in the one hemisphere, while the other is almost wholly occupied by the waters of the ocean. The former (see illustration) is spoken of by



Land and Water Hemispheres.

geographers as the *Continental* or *Land hemisphere*, while the other is termed the *Oceanic* or *Water hemisphere*. These and other noticeable facts connected with the arrangement of sea and land have been often adverted to by writers on geography ; and though it must be confessed that many of their comparisons are more curious than suggestive, it may be suspected that the present arrangement is the result of some great cosmical law—a law concerning the nature of which neither geology nor geography can give any certain indication. This much, however, geology has shown, that the present terraqueous arrangement is not the arrangement that obtained in former ages, and that continents existed where seas now roll, and seas extended where continents are now established. We can often readily account for the minor modifications of coast-lines. Some portions, composed of hard enduring rocks, stand out in bold projections, and constitute our

headlands and capes. Others, consisting of soft and wasting material, are worn into bays, creeks, and irregular recesses. Of the greater forces that slowly upheave some regions and as gradually submerge others, we are, however, altogether ignorant. But while we fail to account for the present distribution of sea and land, and while we find that it is continually undergoing modifications under the operation of geological forces, these changes, on the whole, are so silent and gradual as scarcely to interfere with our conceptions of geographical permanence and stability. The silting-up of lakes, the increase of deltas, the wearing away of coast-lines, the upheaval of one district and the depression of another by earthquake convulsions, and the like, are changes, no doubt, of local importance, but in a general survey of the globe they are scarcely appreciable ; and not till after the lapse of ages does their continuance interfere perceptibly either with the relations of land or water, with conditions of climate, or with the distribution of living forms.

Their Subdivisions, Natural and Technical.

(The Land.)

38. Admitting this condition of the terraqueous surface, it will be seen, on further reference to the map, that the land is broken up into two main masses—that of the Eastern Continent, situated in the Eastern hemisphere, embracing Europe, Asia, and Africa, and described, from its being the only portion known to the ancients, as the *Old World*; and that of the Western Continent, lying within the Western hemisphere, including North and South America, and known (from its comparatively recent discovery by Columbus in 1492) as the *New World*. Properly speaking, there are only two great continuous land-masses or *continents* (Lat. *con* and *tenens*, holding together)—that of the Old World and that of the New; but geographers occasionally speak of six continents or principal sections—viz., those of *Europe*, *Asia*, *Africa*, *North America*, *South America*, and *Australia*. Australia and its contiguous islands, together with those of the Southern Ocean, are frequently grouped as the sixth great division, under the title of *Oceania*; while others, drawing more restricted lines, speak of Australia and New Zealand as *Australasia* (L. *australis*, southern), and of the many islands of the Pacific proper as *Polynesia*¹ (*polys*, many,

¹ A few geographers and ethnographers speak of the East Indian Archipelago as *Malaysia*; of Australia, Papua, New Zealand, and the minor contiguous islands, as *Australasia* or *Melanesia* (*melas*, black), in refer-

nesos, island). The areas of the respective continents, or *quarters*, as they are sometimes termed (though the "four quarters" of our forefathers embraced only Europe, Asia, Africa, and America), have been computed, with their respective islands, as follows :—

Old World, or Eastern Continent,	31,250,000 square miles.
Europe, ...	3,725,000 "
Asia, ...	16,165,000 "
Africa, ...	11,360,000 "
New World, or Western Continent, .	14,900,000 "
North America, ...	8,080,000 "
South America, ...	6,820,000 "
Oceania, or Maritime World, ...	4,200,000 "

39. The Islands included in the above estimate are more or less closely connected with the continents to which they belong, though in truth the continents themselves are merely islands on a much larger scale. In the disposition of the islands, some curious coincidences have been noticed by foreign geographers, but these resemblances are in many instances more fanciful than real, and have no discoverable bearing either on the problems of geology geography. Many of the larger islands—as Iceland, Spitzbergen, or Novaia Zemlia, Madagascar, and the like—are solitary and independent ; others again—as Tierra del Fuego, Sicily, Ceylon, Tasmania, &c.—are curiously connected with the extremity of some peninsula and continent, to which they form, as it were, mere outliers ; while, in a majority of cases, the islands proper are found in clusters or *Archipelagoes* (a term originally applied to Isles of Greece), such as the West India Islands, the Isles of Greece, the East India Islands, the Japan Isles, and the Sandwich Islands. This disposition is no doubt in intimate connection with geological centres of uprise or depression—uprise into new continental areas, or depression into new seas ; but the consideration of such oscillations in the earth's crust belongs more appropriately to Geology than to Physical Geography. Still it is interesting and important for the geographer to understand that by such uprisings islands may be brought into terrestrial contiguity with each other, or with adjacent continents ; while by such depressions lands may be separated into islands, and become widely detached. It is in this way that the flora and fauna of islands often differ from those of the adjacent mainlands, and in some cases present a *facies* that even belongs to some antecedent geological era.

ence to the colour of their aboriginal population ; of the numerous small Pacific islands north of the equator and east of Malaysia, as *Micronesia* (*micros*, small) ; and of the many groups lying south of the equator and east of Australasia as *Polynesia*.

40. In describing the features and peculiarities of the Land, geographers make use of the following designations, which, though familiar in everyday language, may here, for the sake of method, be briefly recapitulated. Thus, a *continent*, as already indicated, is any extensive region uninterrupted or unbroken by seas ; an *island*, any smaller portion surrounded by water ; a *peninsula* (Lat. *pene*, almost ; *insula*, island), a portion nearly surrounded by water ; an *isthmus* (Gr.), the narrow neck that connects two adjacent masses of land, or a peninsula with the mainland ; and a *cape*, *promontory*, *headland*, or *ness*, a point of land jutting out into the water. Besides these terms, which refer to the contour or disposition of the land as connected with water, there are others which relate to surface configuration or vertical relief. Thus, extensive flats are known as *plains*, *steppes*, *prairies*, *pampas*, and the like ; smaller flats as *valleys*, *dales*, *straths*, *carses*, &c. ; lands elevated more or less abruptly above the general surface are spoken of as rising into *hills*, or still higher into *mountains* ; hills and mountains may stand less or more apart from each other and be *isolated*, may occur in *groups* as if connected with a common centre, or they may stretch away in determinate courses known as *chains* and *ranges* ; while level elevated tracts are spoken of as *table-lands* and *plateaux*.

(The Waters.)

41. Though encircling the globe on every side, and in all its parts most intimately connected with one great ocean, the Water is still divisible into certain areas that are more or less defined by the intervention of the land. Thus, on the west of the Old World, and between it and the New World, extends one main division known as the *Atlantic* (so called by the ancients from its washing the western base of Mount Atlas in Africa) ; on the west of the New World, and between it and the Old, expands another natural division known as the *Pacific* (from its comparative freedom from storms) ; while between Australia and its contiguous islands on the east and Africa on the west, lies the *Indian Ocean*. It is usual, however, to speak of *five* great oceans—viz., the *Atlantic*, *Pacific*, *Indian*, *Arctic*, and *Antarctic*—the two latter being, respectively within the arctic and antarctic circles. In geographical descriptions it is also useful to employ the terms “North and South Atlantic,” and “North and South Pacific,” and to speak of the expanse that stretches away in unbroken vastness between the Indian Ocean and the south pole as the “Great Southern Ocean.”

The areas of the three chief expanses are usually estimated as follows :—

Pacific Ocean,	.	.	50,000,000 square miles.
Atlantic Ocean,	.	.	25,000,000 ,,
Indian Ocean,	.	.	17,000,000 ,,

42. In treating of the waters of the globe, though there is, strictly speaking, only one great ocean, the term *ocean* is applied to the large uninterrupted expanses above defined ; smaller areas are known as *seas* ; gradual bendings of the water into the land as *bays* ; deeper indentations as *gulfs* ; minor and sudden indentations as *creeks*, *inlets*, *arms*, &c. ; the narrow belts or openings connecting two adjacent seas as *straits*, or *channels* ; and where the sea stretches inland to receive the waters of a river, such an expanse is known as a *frith* or *estuary*. Besides these general terms, there are others of a more local and restricted character, as the *fiords* or rocky inlets of Norway—the *lochs*, or lake-like sea-arms of Scotland—the *lagoons*, or shallow intercepted sheets that occur along the shores of the Adriatic and other seas ; but these will be best described under the respective areas to which they belong. Again, referring to the depth of the ocean, whose bed seems to be as irregular and varied as the surface of the dry land, geographers speak of *deeps* and *pits* ; of *shoals* and *banks* ; of sounds that may be readily reached by the sounding-line ; of *roads* and *roadsteads* for anchorage ; of *harbours* or landlocked inlets for shelter ; and similar terms, whose meanings are so obvious as to require no special definition.

43. Besides the great oceans and inland seas above alluded to, and which all consist of salt water, there are other considerable volumes that belong more especially to the land, and which consist mainly of fresh water, comparatively few being brackish or saline. These are the *springs*, issuing from the earth's crust, and more or less impregnated with the mineral substances through which they have percolated ; the *streams*, or runnels of water formed by the union of several springs ; the *rivers*, formed by the union of streams, and often traversing whole continents with gradually increasing volumes ; and the *lakes*, which occupy depressions in the land, and most frequently lie along the courses of rivers, though occasionally occurring isolated and apparently fed by springs, or, if receiving the waters of a river, have no river of discharge, but give off their surplus water by evaporation. The amount of surface occupied by these inland waters it is impossible to estimate with anything like accuracy ; and this difficulty is greatly increased by the fact that, in countries subject to periodical

rains, many tracts which become lakes and rivers during the wet season, are mere swamps and dry shingly channels when the period of drought returns. The main volumes of fresh water, as will be seen when we come to treat of the "River-systems," are the North American lakes, the lakes of Northern Europe and Central Asia, and the greater and more permanent rivers—as the St Lawrence, Mackenzie, and Mississippi in North America ; the Amazon, Orinoco, and La Plata in South America ; the Nile, Niger, and Zambezi in Africa ; the Ganges, Indus, Yang-tse-kiang, Lena, Yenesei, and Obi in Asia ; and the Volga, Danube, and Rhine in Europe. Springs, streams, rivers, lakes, and seas thus constitute what may be termed the geographical phases of water, or, in other words, its position and disposition on the earth's surface. Water, however, is circling everywhere, and is everywhere present, either in its aeriform, liquid, or solid condition. Floating in the air that surrounds us, in visible or invisible vapour, circulating in the tissues of plants and animals, embodied in the substance of the hardest rocks, coursing over the earth's surface, or percolating deep in the solid crust, it is the great vital fluid of the globe by which its crust is permeated, combined, dissolved, reconstructed, and vivified in endless revolution and progress.

Their Mutual Actions and Reactions.

44. Such is the relative distribution, and such the general features of the land and water that form the surface of the terraqueous globe. Whatever may have been their distribution in former ages as revealed by geology, one thing is obvious, that in the present era they are, within certain limits of change, mutually adapted and harmoniously adjusted. The land is more rapidly heated and cooled superficially than the water ; and thus, while parched and thirsty in summer, it is refreshed and vivified by the moisture evaporated from the more extensive ocean ; while in winter its tendency to grow colder is modified by the heat given off by the ocean, whose slower radiation renders it, as it were, a great storehouse of heat for the exigencies of the land. Besides this interchange of heat and moisture, there is also the interchange of aerial currents and winds, caused by the unequal effects wrought upon the two great surfaces by the heat of the sun ; and thus, as will be more fully explained hereafter, the whole machinery of climate—hot winds, cold winds, vapours, rains, and the like—is set agoing by the primary differences existing between land and water. As the terraqueous surface is at present arranged, a certain amount

of moisture is evaporated from the ocean and carried to the land, a certain amount of heat is interchanged—certain winds blow at certain seasons, certain tides rise and fall, and certain currents flow in the performance of certain functions ; but all this would be changed by the slightest alteration either in the relative areas, in the relative configurations, or in the relative positions of land and water. In their present areas, configurations, and dispositions, the two elements are harmoniously co-adapted for the production of certain results, geological, climatological, and vital ; and the student must readily perceive how the force of tides and waves and currents would be altered, the climate of regions changed, and their plants and animals affected by the slightest disturbance in the existing terraqueous arrangements. Let North and South America be severed by the disappearance of Panama—let the bed of the Atlantic be upraised so as to deflect the Gulf Stream on the coasts of Greenland, instead of those of Europe—let the central plain of Europe be submerged so as to be occupied by another Mediterranean,—let these or any similar set of changes be effected on the present arrangement of the continents and oceans, and a whole host of new secondary influences would be set in motion, altering the climates, and modifying the kind and character of the plants and animals that people these regions. So intimately, in fact, do the conditions of the one element depend upon those of the other, and plants and animals upon both, that not a league of land could be converted into sea, or a league of sea-bed upheaved into dry land—the land raised a foot higher or the sea become a foot deeper—without a corresponding change being effected on the whole economy, physical and vital, of our planet.

From Nature's chain whatever link you strike,
Tenth or ten-thousandth, breaks the chain alike.

NOTE, RECAPITULATORY AND EXPLANATORY.

The surface of the globe, or that which comes in contact with the atmosphere, is partly occupied by land and partly by water—the former constituting more than a fourth, and the latter about three-fourths of the entire area. On a cursory inspection of the Map of the World, the land will be seen to resolve itself into two main masses—the Eastern Continent or Old World ; and the Western Continent or New World ; and these by geographers are usually further subdivided into the so-called “quarters” or

continents of Europe, Asia, and Africa in the former; North and South America in the latter; together with a south or insular division, embracing Australia, &c., under the name of Oceania. Of these continents the greater portion lies in the northern hemisphere, the broader masses spreading out towards the north, and gradually narrowing towards the south in the cape-like projections of South America, Africa, Hindostan, and the Malayan Peninsula. The ocean, though encircling the globe on every side, and stretching from pole to pole, is also arranged in areas more or less defined by the intervention of the land-masses. The main divisions are the Atlantic, the Pacific, Indian, Arctic, and Antarctic Oceans, which, for convenience of description, are frequently subdivided into North and South Atlantic, North and South Pacific, Northern, Southern, and Polar Seas. The physical results arising from the present distribution of sea and land are manifested chiefly in tides, currents, unequal reception and radiation of the sun's heat; and as a consequence, winds, vapours, rains, and all the other phenomena that give rise to climatic diversity. What may be the proximate cause of the present arrangement of sea and land—why the land should lie chiefly in the northern hemisphere, and largely within the temperate zone, while it disappears in a succession of narrow cape-like lobes towards the south—neither Geology nor Geography can determine. One thing, however, is certain, that it is part of a great geological sequence of continuous oscillations between sea and land, each change being attended by its own physical and vital phenomena; and that, as in the past history of the globe, so in the present, no alteration in this terraqueous arrangement can take place without a corresponding alteration in all the essentials of Physical Geography. We could not, for example, alter the disposition of any of the great continents, nor upraise it, nor depress it, without interfering to that extent with all its oceanic and climatic phenomena, and as a necessary consequence with the nature and distribution of its flora and fauna. And not only with the flora and fauna, but with its human occupants also in all that relates to their physical and mental peculiarities—their avocations and industries. "Every mountain," says M. Reclus, "every headland, every islet, every lake, river, or rivulet, plays its part in the history of mankind."

V.

THE LAND—ITS CONFIGURATION.

45. HAVING glanced at the distribution of land and water, and their general relations to each other, as composing the terraqueous surface of the globe, we now proceed to consider their special features—the mountains, table-lands, plains, and valleys of the one ; the composition, depth, temperature, tides and currents of the other. And first, in the present chapter, of the Land, whose features are more within our reach, and have been longer and more minutely the subjects of geographical investigation. How is this dry land disposed on the surface of the globe? This is its *position* as depending on latitude and longitude. What is the outline of its form or shape as regards the ocean, by which it is on every side surrounded? This, in geographical language, is its *contour*. How, again, does it rise above the waters; and what are the surface inequalities presented to the atmosphere? This is its *vertical relief*. Position is the place it occupies on the surface of the globe; contour the outline bathed by the waters of the ocean; vertical relief the surface-line that rises into the atmosphere; and the student will readily perceive that upon these three elements of position, contour, and relief, depend the climate, physical aspects, and vital diversity of any portion of the dry land.

Relative Position.

46. Latitude and longitude, we have said, determine the position of any spot on the earth's surface, be it islet, island, or continent; and just as these limits bring it within tropical, temperate, or arctic zones, so will its climate and products assume aspects of a corresponding character. No doubt climatic conditions are greatly modified by contour and altitude, but position is the main determinator of a country's character, and must ever continue to

be so under the existing relations of the earth in the solar system. How different, for instance, would have been the physical and vital characteristics of Europe and Asia had they lain mainly within tropical, instead of stretching, as they now do, mainly along temperate latitudes! How different, also, the condition of North and South America, if, instead of stretching from north to south, through all the different zones of temperature, they had lain, like the Old World, from east to west, along the same parallels of latitude! And how altered, in like manner, had been the physical, vital, and perhaps also the intellectual, characteristics of Great Britain, if, instead of trending northward and southward, between the 50th and 60th parallels, it had stretched westward to the same extent into the waters of the Atlantic! Position, in fact, is an all-important element in geography. The cause of the present position of the dry land lies far, as yet, beyond the indications of science. We learn from Geology that the existing position is not that which obtained in former ages; and that, in fact, every epoch was characterised by its own special distribution of land and water, and of necessity by its peculiar climatic and vital appointments. The consideration of these alternations belongs to Geology: Geography has mainly to deal with the existing aspects of nature.

Contour or Horizontal Outline.

47. Though Geology and Geography are alike unable to account for the present disposition of sea and land, there are still some features in the contour of the respective land-masses that demand a passing notice. Not that we know the producing cause of these features, nor that they are deserving the attention occasionally bestowed upon them, but simply because they are arrangements productive of obvious results. Thus:—

1st. The greatest extension of the Old World continent is from east to west, while that of the New World is from north to south. In this way, the Old World, lying largely along the same zones, presents a greater uniformity of external conditions; while the New World, crossing the zones—frigid, temperate, and torrid—is subject to a greater diversity of temperature, and, as a consequence, to all the conditions that arise from this diversity.

2d. Both continents attain their greatest dimensions from east to west along the same parallel of latitude—namely, that of 50° N.—a disposition that places much of North America, Europe, and Asia within the temperate zone, while only the narrower

portions of South America, Africa, and the East India Islands lie directly under the burning heat of the equator.

3d. Both continents, as formerly noticed, spread widely towards the north, where they nearly approach each other, and terminate broadly along the same parallel (72° N.) or nearly so; while, towards the south, they gradually grow narrower, and terminate in far-separated promontories.

4th. The continents are arranged in pairs—the larger continent of each pair lying to the north. Asia is wholly divided from Australia by the East India Straits, Europe from Africa, while North America is almost as practically divided from South America by the Carribean Sea.

5th. The direction of all the principal spurs and peninsulas in both continents (California, Florida, Greenland, Scandinavia, Spain, Italy, Greece, Hindostan, Malaya, Kamtchatka, &c.) is towards the south.

6th. These southward-trending spurs, moreover, are in most instances curiously accompanied by an outlying island or islands—as South America by Tierra del Fuego and the Falkland Islands, Africa by Madagascar, Hindostan by Ceylon, and Australia by Tasmania. And in connection with this may be noticed the fact, that these promontories terminate in abrupt rocky precipices—as Cape Horn, in Tierra del Fuego; Cape of Good Hope near its Table Mountain; Cape Comorin, in India; and Cape South-East, in Tasmania—all the broken and worn extremities of expiring mountain-chains.

7th. The general disposition of the continents and larger islands is in the direction of their principal mountain-axes; so that, given the direction of the mountain-chains, we know the longitudinal disposition of a continent, or given the direction of a continent, and we can foretell the strike of its mountains.

8th. All the continents have elevated mountain-borders, and low basin-like interiors. Thus North America is margined on the one side by the Rocky Mountains, and on the other by the Alleghanies, while the basin-like plain of the Mackenzie and Mississippi occupies its interior. South America is bounded on the west by the Andes, and on the east by the Brazilian Cordilleras, which include between them the vast hollow of the Orinoco, Amazon, and La Plata.

9th. The larger mountain-border faces the larger ocean. Thus the elevated range of the Andes overlooks the wide Pacific, while the less elevated Brazilian ranges face the Atlantic.

10th. The marked resemblances that obtain—between North America with the West India Islands on its south-east, Europe

with the Grecian islands on its south-east, and Asia with the Indian Archipelago in the same quarter, are curious coincidences that have been long noticed by geographers.

11th. The general tendency of islands to arrange themselves in clusters or archipelagoes, is a fact suggestive of a common geological cause.

12th. The numerous indentations of the sea, that confer irregularity and extent of coast-line on the land in the northern hemisphere, form a feature that strongly contrasts with the uniform and unbroken coasts of South America, Africa, and Australia, in the southern hemisphere.

48. This last relation—viz., that of a broken and deeply indented coast-line, furnished with peninsulas, gulfs, inland seas, and harbours—is one of the most important in Physical Geography, as on it depend greater diversity of climate and productions, and all those facilities for navigation and commerce which confer on nations their wealth, power, and independence. Europe and North America stand pre-eminent for their relative extent of coast-line; and hence in a great measure their industry, maritime enterprise, and civilisation. We may assume that the capacity of a country for external communication can in some degree be estimated by the proportion of its coast-line to its superficial area.

We have already shown that Europe has 1 mile of coast for every 143 square miles of surface, and North America 1 mile of coast for every 265 square miles of surface—a proportion more than double that of the other continents; hence one great physical reason for the maritime and commercial supremacy of their populations. In the higher stages of his civilisation and scientific skill, man has nature to a certain degree under his control and modification; but in the main his progress is not only fostered, but to a great extent educed, by the physical conditions of the region he inhabits.

49. Besides the preceding analogies, there are several others that have been noticed by geographers; and though such comparisons are often more fanciful than real, they are all less or more suggestive, and may occasionally lead to a satisfactory theory. But whatever may have been the causes that produced the present arrangement of the land-masses, no change could take place in their relative situations without being attended by corresponding changes in the nature of their climate, and in the character of their vegetable and animal inhabitants. Had they lain chiefly within the tropics—been situated partly in the northern and partly in the southern hemisphere, with a broad belt of tropical ocean between—been arranged either longitudinally or

latitudinally in parallel zones, or been broken up into smaller masses by the more frequent intervention of the ocean—a totally different set of climatic agents would have prevailed, and been consequently attended by a totally different distribution of plants and animals. During geologic changes, when large tracts are being gradually submerged and others are gradually elevated into dry land, whole races of plants and animals are extinguished, while others shift ground and find means of dispersion over the newly elevated regions. At present the plants and animals of the Old World differ from those of the New, those of North America differ considerably from those of South America, those of Europe from those of Africa, and those of Asia from those of Australia; but these differences would have been still more striking and decided had these continents lain still more apart, or been more widely separated in their geological connections. As it is, and in the language of M. Guyot, “each of these terrestrial masses, considered as a whole, as an individual, has a particular disposition of its parts, of the forms which belong to it—a situation relatively to the rays of the sun, and with respect to the seas or the neighbouring masses—which is not found identically repeated in any other. All these various causes excite and combine, in a manner infinitely varied, the play of the forces inherent in the matter which composes them, and secure to each of them a climate, a vegetation, and animal life; in a word, an assemblage of physical characters and functions which are peculiar to it, and which really give it something of individuality.”

Vertical Relief or Elevation.

50. Next to the *contour* or horizontal configuration of the land, the most important feature is its *vertical relief*, or elevation above the level of the ocean. As the position of an island a few degrees farther north or south, its disposition along the parallels of latitude or along the meridians, or its configuration as broken up by seas or lying in one unbroken mass, must each affect the nature of its climate, so its vertical relief is productive of similar results—every rise of 300 or 350 feet being sufficient to diminish the temperature by about one degree of Fahrenheit. If we cannot determine with satisfaction the causes that have produced the existing position and contour of the continents, we know, at least, that the main instruments of their surface diversity into mountain and valley, table-land and plain, are the volcanic forces acting from within, and the forces of erosion and transportation as per-

sistently acting from without. The former, in obedience to some great law, have been continuously but irregularly shifting place from the earliest traces of geologic history ; at one time, and prevailing extensively, along the old primary ranges of Europe, Asia, and Africa—at another, and with equal intensity, along the secondary hills of the same continents—and now, with apparently unabated vigour, along the main ridges of modern America, the islands that fringe the eastern shores of Asia, and the groups that stud the bosom of the Pacific. These successive shiftings and upheavals form, in fact, part and parcel of the great machinery of the world's evolution—a machinery by which the sea-bed is upheaved into new land, and old surfaces submerged beneath the ocean, and this continuously, successively, and, in all likelihood, in a determinable order, which Geology will one day or other be enabled to discover. The student cannot cast his eyes over a Map exhibiting the present terrestrial distribution of Earthquakes and Volcanoes, and observe the paucity of volcanoes in several large tracts of the world, as contrasted with their great concentration in groups and lines along the shores and over the surface of the Pacific, without being impressed by the conviction that in the last-named region some great cosmical change is in course of elaboration. We say, *in course of elaboration* ; for, like all other gigantic operations in nature, the upheaval of continents, and the up-piling of mountains and the evolution of mountain-chains, are the works of innumerable earth-throes and volcanoes operating through untold ages. Besides the more obvious operations of the earthquake and volcano, there is also that slow but gradual elevation and depression of vast regions (*e.g.*, the uprise of Northern Scandinavia, the depression of South Greenland, the uprise of the Arctic Islands, &c.), which in course of time must effect most important changes ; and to these combined forces, assisted by the wasting and wearing of water in all its forms—rain, rivers, and glaciers—are to be mainly ascribed the principal features in the vertical relief or superficial diversity of the land.

51. Among these features may be noticed, 1st, That in all the continents (exception being made of a few depressed areas, such as those occupied by the Caspian, Dead Sea, &c.), there is a gradual rise from the sea-shore towards certain points or ridges in the interior. These ridges, or points of maximum swell, form the grand *watersheds* of their respective continents ; and a glance at the courses of the principal rivers will at once direct the eye to the line of these mountainous elevations.

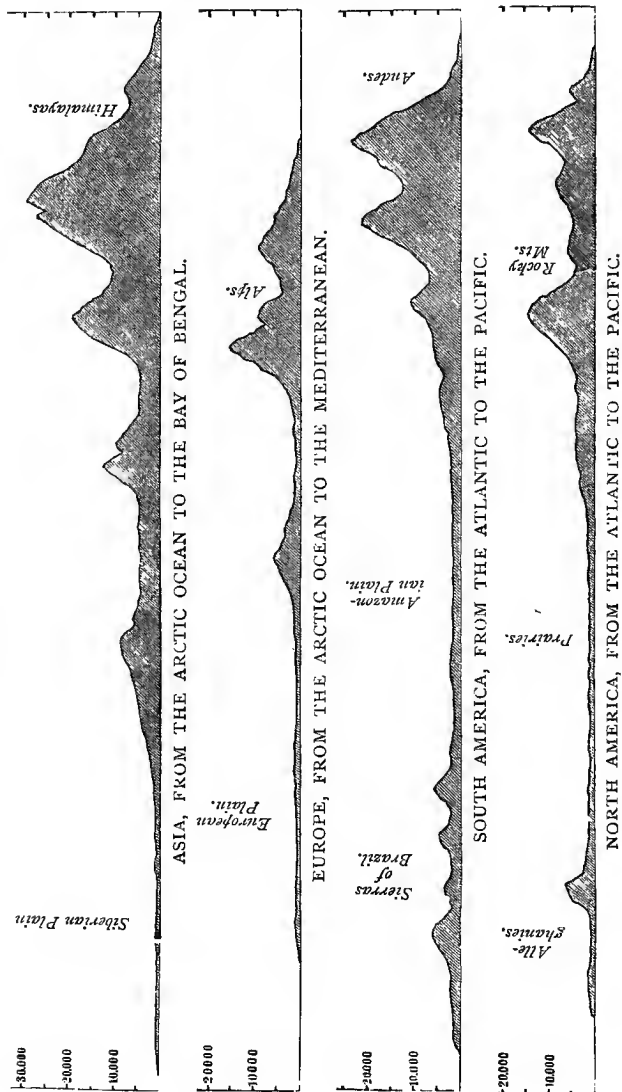
2d. In all the continents this line of greatest elevation does not occupy the centre, but is placed more towards one side than

another ; hence arise two gradients of unequal length, the long side forming the *slope*, and the shorter the *counter-slope*, of the continent. In the Old World the long slopes are turned towards the north, and the short towards the south ; while in the New World the gentle slope is towards the east, and the short and rapid one towards the west.

3d. Though this difference of arrangement in the slope and counter-slope takes place in the two worlds, a general flattening of the land towards the north, and a general rise and irregularity of its surface towards the south, prevail in all the continents. "The effect of this law of arrangement," it has been well observed, "is to temper the burning heats of the tropical regions, and to give them a variety of climate which seems not to belong to these countries of the globe. If this order were reversed, and the elevation of the lands went on increasing towards the north, the most civilised half of the globe, at the present day, would be a frozen and uninhabitable desert."

52. As another general law it may be stated, 4th, That the grand elevations or mountain-ranges lie in the direction of the greatest length of a continent ; in other words, it is the great lines or *axes* of upheaval that confer on the continents their main relief or configuration. Thus, in the New World, whose greatest length is from north to south, the ranges of the Andes and Rocky Mountains, the Cordilleras of Brazil, and the Alleghanies of the United States, stretch all less or more regularly in the same direction. In the Old World, on the other hand, whose greatest length is from east to west, the ranges of the Pyrenees, Alps, Carpathians, Caucasus, Himalayas, and Altai, lie chiefly in the same direction, throwing the great rivers to the north and south of these watersheds. The backbone, if we may so speak, of the New World is the great mountain-chain, or rather chains, that extend in the same linear direction from Patagonia on the south to Russian America on the north—a length of about 8000 miles ; while the backbone or framework of the Old World is similarly composed of a series of ranges that extend with but little interruption from the Pyrenees on the west to Kamtchatka on the east.

5th. As with the continents, so with the principal islands and peninsulas : they are all less or more continuously traversed by mountain or hill ranges in the direction of their greatest length—as witness Scandinavia, Italy, Greece, Kamtchatka, Malaya, the islands of the Indian Archipelago, Madagascar, California, and Greenland. In fact, it is the mountain-ranges that determine the strike of the land, and confer on these spurs and peninsulas their elongated forms.



53. Reserving the arrangement of the world's highlands into mountain-chains and systems for subsequent consideration, it may be noticed in the mean time that the loftiest ridges in the vertical relief of the land are those of the Himalaya in Central Asia, whose highest peak is, in round numbers, 29,000 feet; next, those of the Andes in South America, 24,000 feet; the Cordilleras of Mexico in North America, 17,740 feet; the Alps in Europe, 15,780 feet; the eastern mountains in Africa, 20,000 feet; and the highest ascertained points in Malaya, Australia, and Polynesia, respectively 15,000 feet, 7000 feet, and 16,000 feet. These altitudes, however, convey no idea of the general relief of the several continents, whose superficial aspects depend more on the table-lands and plains, the hill-ranges and valleys, than on the extreme heights of their principal mountains. Indeed, so small a proportion do these extreme ridges bear to the great mass of the continents, that it has been calculated by Humboldt that the Alps spread equally over the surface of Europe would raise the general level not more than 21 feet; while the vast mountain-chains of Asia, treated in a similar manner, would not add more than 150 feet to the general elevation of that continent. Blending all their heights and hollows into a general average, the *mean elevation* of the respective continents above the sea-level have been calculated as follows:—

Europe, 1342 feet; Asia, 2264 feet; North America, 1496 feet; South America, 2302 feet; Africa, 1800 feet; and Australia, 500 feet. Or taking the whole—continents and islands, mountains and plains—the mean elevation of all the land has been estimated at somewhat less than 1000 feet.

Causes and Consequences of Configuration.

54. It will be seen from the preceding paragraphs that the three great elements in the configuration of the land are relative position, contour, and vertical relief. By *relative position* is meant the place an island or continent occupies on the surface of the globe; and just as this position is frigid, temperate, or tropical—as it lies on broad parallelism along the same zone, or crosses meridionally two or more zones—so will its climate be genial or ungenial, uniform or diversified. The causes that have determined the position of the existing continents lie far, as yet, beyond the indications of science, though we may rest assured that, in the gradual shiftings of volcanic energy from centre to centre, and in the alternate uprise and submergence of large tracts of the

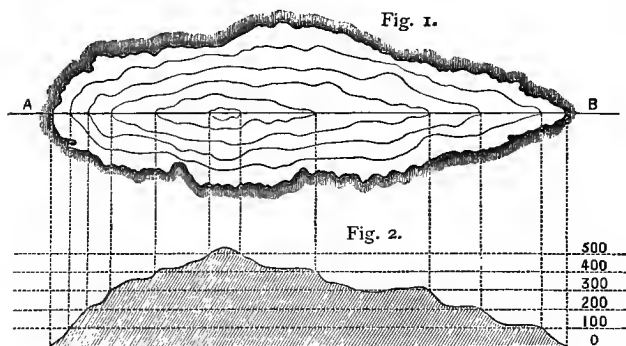
earth's crust, we behold the results of a definite and continuously operating law. By *contour* is meant the outline or figure which the land receives by being surrounded by the water ; and just as this outline is simple and uniform, or irregular and indented by seas, bays, and gulfs, so will its external conditions be varied, and its coasts better fitted for the purposes of navigation and commerce. This contour depends mainly, of course, upon the original inequalities of the crust, but partly also upon the waste and degradation which all coast-lines undergo from the ceaseless action of the ocean—the softer rocks being worn into creeks and coves, while the harder stand out in headlands and promontories. Combined, as in the case of Europe, with favourable relative position, this varied configuration exercises most important influences on climate, productions, industry, enterprise, and civilisation. By *vertical relief* is meant the elevation of the land above the level of the ocean : and just as this is regular or irregular, low or lofty, so will the whole character of a country be determined. A few hundred feet more or less of elevation is sufficient to change the whole physical aspects of a country—converting arable fields and vineyards into pasture-lands, pasture-lands into pine-forests, and pine-forests into regions of everlasting snow and glacier. This vertical relief of continents and islands depends, as already noticed, mainly on their lithological or rocky structure, on the intensity and continuance of the elevatory and volcanic forces to which they have been subjected, and on the amount of waste and degradation—chiselling, if we may so speak—they may have subsequently undergone. Thus, during the slow oscillations of the earth's crust, there are few tracts of the existing land that have not been more than once under the waters of the ocean ; hence the amount of denuding, smoothing, and rounding of their reliefs. There are also few tracts that have not been subjected to a recurrence of elevation or volcanic activity ; and hence, in proportion, the greater height, irregularity, abruptness, and variety of their surfaces. And even after elevation into permanent islands and continents, these surfaces are all less or more subjected to aqueous and atmospheric agencies—the wearing of frosts and rains, the erosion of waves, and the grinding of glaciers—which are slowly but irresistibly moulding them into newer outlines, according to the harder or softer nature of the rock-materials that compose them. The relief of the land is thus a thing of slow but incessant fluctuation, affected by every uprise and depression of the earth's crust, by every volcanic outburst, and by every action of the aqueous and atmospheric forces that waste and wear down the exposed surfaces. So gradually, however, do these forces operate,

that no appreciable change is produced for centuries ; and thus we are led to associate ideas of permanency with what in reality is incessantly but infinitesimally changing. But whatever may be the causes of position, contour, and relief, they are all-powerful in modifying and regulating the climatic and vital conditions of a country. Thus, the *position* of our own islands confers on them a temperate though somewhat fickle climate ; their *contour*, with its bays and friths and estuaries running deeply into the land, affords unusual facilities for navigation and commerce ; while their *relief*, with its heights and counter-slope to the west, and its longer slope and plains to the east, renders the western districts more hilly and humid and pastoral—while the eastern are spread out in plains with a decreased rainfall, and are better adapted for the requirements of grain-growing and miscellaneous husbandry.

NOTE, RECAPITULATORY AND EXPLANATORY.

The facts connected with the general configuration of the land have been so fully stated in the preceding chapter, that very little additional explanation is required. Relative position, contour, and relief, are alike influential in modifying the external conditions of a region. Latitude and longitude determine the position ; a sufficient number of similar observations fix the contour ; and trigonometrical survey, or barometrical observation (mercurial or aneroid) can define the relief or outline of elevation. Position and contour are readily shown on maps by actual outline ; relief can be indicated by a scale of shading, or more accurately by a system of contouring. Thus, taking the shore-line, which is all on the same level, as the first contour, we may have similar lines taken at every 50 feet or every 100 feet of ascent, and these (when the observations are sufficiently numerous) will exhibit, with great accuracy, the risings and fallings of the surface configuration. Such a series of lines gives, as it were, the moulding or model of the surface ; and a section of this model, in any direction, will show the profile for that direction. Suppose an island, for example, with its contours taken at every 100 feet of ascent, to be represented by fig. 1 ; then fig. 2 will show the same in profile or absolute elevation in the line of section A B. The closer the lines of contour lie together, the more rapid or steeper is the ascent ; and the more widely apart they are, the

flatter is the slope of uprise. It is by sections developed in this manner that the profiles of the different continents are usually shown by geographers, as will be more fully illustrated when we come to treat of the mountains and table-lands in the succeeding chapters.



Contour and Profile.

Should the student desire to enter more fully into the subject of position, contour, and relief, with their ultimate bearings on the features and characters of the respective continents, he will find more ample details in Guyot's 'Earth and Man;' in Mrs Somerville's 'Physical Geography;' in M. Reclus's 'Earth;' and in several of the chapters of Humboldt's 'Cosmos.'

VI.

THE LAND—ITS HIGHLANDS.

Mountains and Mountain-Systems.

55. HAVING directed attention to the general configuration of the land as dependent on its contour and relief, we now proceed to describe the special features of that relief as exhibited in its mountains and mountain-chains, its table-lands and plateaux. In the first place, we shall treat of the mountains, which have long attracted the attention of geographers, as one of the most obvious causes of climatic, vital, and political diversity. Defining a mountain as "any portion of the earth's crust rising considerably above the surrounding surface," we must recollect that mountain-ranges are not mere *ridges*, rising abruptly on one side and descending as abruptly on the other ; but that they are in reality elevated tracts, often of great breadth as well as length, and consisting of rounded heights, lofty peaks, and boldly escarped plateaux, with intervening valleys. As, *geographically* speaking, a mountain-range is not a single ridge of elevation, but a brotherhood of many elevations ; so, *geologically* speaking, it is not a simple upheaval, the result of one paroxysmal outburst, or of one swift and sudden crushing together of its component rock-formations, but the work of innumerable volcanic outbursts, or of many slow and long-continued compressions, and subsequent erosions and denudations, operating through countless ages. A mountain-chain ten or twenty thousand feet in height and hundreds of miles in length, is thus a thing of slow and gradual growth ; upheaval after upheaval, and eruption after eruption—now with widespread intensity, now slumbering for generations, and again with renewed activity—each contributing to augment the mass of final elevation and accumulation. And as the times of contortion, upheaval, and accompanying volcanic action usually alternate with periods of

comparative repose, gentle depression, and quiet deposition, we are able to judge of the relative ages of the formation of the several axes of mountain-ranges, by comparing the geological dates of the contorted and disrupted strata out of which they are composed, with that of the gently sloping and undisturbed beds which repose upon their flanks, and say whether they were formed during primary, secondary, or tertiary eras. Again, by noting the direction of these axes of upheaval and the varying nature of the strata affected—whether consisting, on the one hand, of intractable granitiform, slaty, or schistose metamorphic rocks; or, on the other, of the comparatively soft and easily eroded sandy, shaly, and finely laminated beds of the fossiliferous systems—Geology enables Geography to account for the external characters of mountains, and to explain why some should be massive and rounded in outline, others serrated with splintery peaks and pinnacles—some conical and dome-shaped, and others again terraced by crags, and sloping away in long gentle declivities. It is in this way, also, that geologists speak of mountains of *upheaval*, of *accumulation*, and of *circumdenudation*,—meaning by the first, those which consist chiefly of upheaved strata; by the second, those formed mainly of volcanic eruptions; and by the third, those which consist of harder rocks (stratified or unstratified), that stand up while the softer materials which originally enveloped them have been worn and washed away.

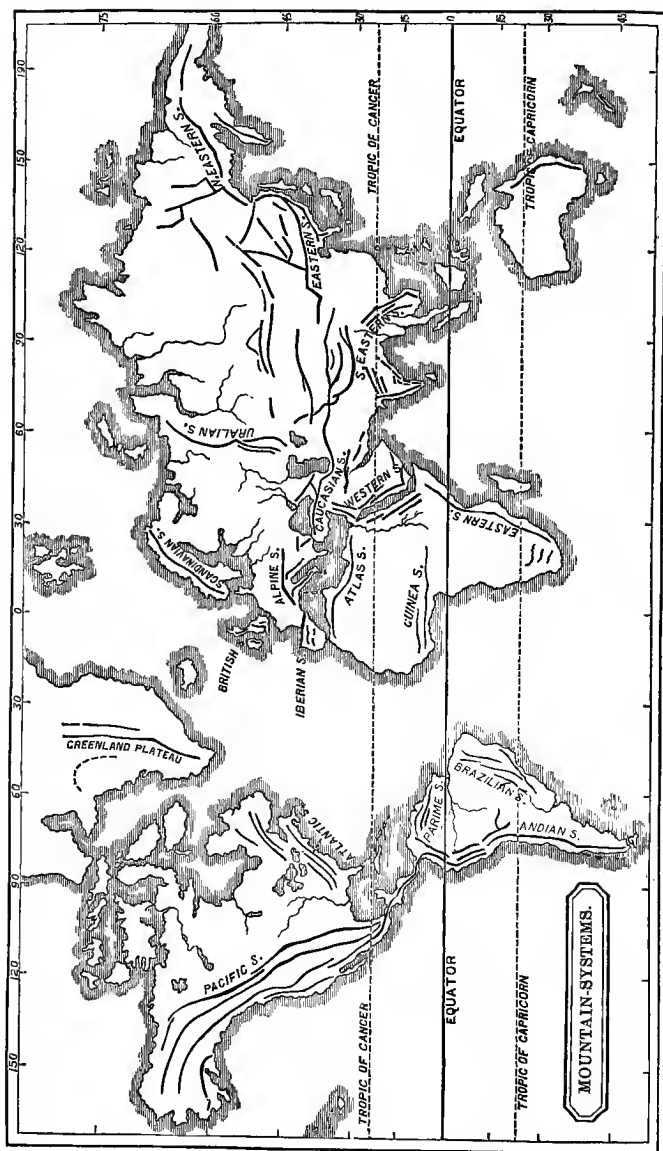
56. Understanding the general character and formation of mountainous elevations, we may explain that the term *mountain* is usually applied to heights of more than 2000 feet—all beneath that height being regarded as *hills*, and those of still minor elevation as *hillocks*. A *mountain-chain* or *mountain-range* is a series of elevations having their bases in contact, and their axes or lines of elevation continuous, over a considerable extent of country—as the Grampians, Urals, or Andes; a *group* consists of several ranges more or less connected; and a *system*, of several groups that evidently belong to the same set of geological operations. Mountain-summits are distinguished by such terms as *cones*, when gradually tapering to a point, as in volcanoes; *domes*, when more massive and rounded; *peaks*, when abrupt and insulated; by the Spanish word *sierra*, when their outlines show a succession of peaks; and by the French word *aiguilles*, or *needles*, when still more pointed, splintery, and detached. The terms *undulating*, *serrated*, *rugged*, and the like, applied to their outlines or profiles, are so familiar in everyday language, as to require no special explanation. Mountain-sides consist of *slopes*, *terraces*, *escarpments*, and *precipices*, or of a combination of these; and these outlines

depend chiefly on their geological structure, and partly on the amount of waste and degradation to which they have been subjected. In general, mountain-ridges have a long, gentle declivity on one side, and a short and abrupt one on the other ; and where this occurs, the longer declivity is spoken of as the *slope*, and the shorter one as the *counter-slope*. This slope and counter-slope is equivalent to what is known in Britain as "*crag and tail*,"—most of our isolated hills presenting a bold precipitous front or crag to the west or north-west, and a long slope or tail to the east or south-east. The depressions and narrow valleys which occasionally intersect mountain-chains are known as *defiles* and *passes*; and these, offering, as they often do, the only means of transit across mountain-barriers, have ever been objects of political and commercial importance. The outlines of mountains depend chiefly on their geological structure, and partly, also, on the amount of waste and degradation to which they have been subjected. It is in this manner that hills composed of hard basalts and greenstones, alternating with soft tufas or stratified rocks, assume *terraced* declivities (*trap-hills*); that extinct volcanic hills, like those of Auvergne, put on a *crateriform* aspect; that those largely composed of hard massive strata—as limestone, conglomerates, and sandstones—present a *tabular* appearance with *mural* (wall-like) precipices; and that mountains capped and flanked by crystalline schists of unequal hardness are *serrated* with peaks and pinnacles. To the skilled geographer every mountain and mountain-chain has, if we may so speak, its own physiognomy—a physiognomy which bespeaks not only its original rocky structure, but to a great extent the nature of the external forces by which it has been carved into its present outlines.

57. With these explanations, the principal MOUNTAIN-SYSTEMS may be here enumerated—the student remembering that there is much in this arrangement that is arbitrary and provisional. Thus—

In EUROPE, geographers usually distinguish the *British system*, comprising the Grampians, Cheviot, Cumbrian, Cambrian, and Hibernian ranges; the *Iberian* or Spanish, embracing the Pyrenees, the Cantabrian Mountains, the Sierra Morena, Sierra Nevada, and the sierras of the central table-land; the *Sardo-Corsican*, consisting of the mountainous range of Sardinia and Corsica; the *Alpine*, including the Alps proper, Apennines, Carpathians, Balkan, and Hellenic ranges; the *Scandinavian*, or mountain plateaux of Norway and Sweden; the *Sarmatian*, or central high-ground of Russia; the *Uralian* and *Caucasian*.

In ASIA we have the *Western system*, comprising the Taurus,



** The heavy lines indicate the extent and direction of the principal Mountain-Systems as usually defined by geographers.

Anti-Taurus, Lebanon, Armenian, and Elburz ranges ; the *South-eastern system*, embracing the Hindoo Koosh, the Himalaya, and the mountains of Burmah, Siam, and Cochin-China ; the *Eastern system*, comprising the Kuen-lun, the Pe-ling, Yun-ling, Kihan-shan, In-shan, and other Chinese ranges ; and the *North-eastern system*, extending from the Bolor Tagh in the centre of the continent to Behring Strait, and comprehending the Thian-shan, the Altai, Yablonoi, and Stannovoi ranges.

In AFRICA we find the *Atlas system* between the shores of the Mediterranean and the Sahara ; the *Guinea system*, embracing the Kong and Cameroon Mountains ; so far as is known, the *Eastern system*, comprehending such as the Drakenberg, Lupata, and other contiguous ranges ; and the *Cape system*, consisting of several parallel ranges, which increase in altitude from Cape Town to the interior.

In NORTH AMERICA occur the *Pacific system*, better known as the Rocky Mountains, in the west ; and the *Atlantic or Appalachian system* (Alleghanies, &c.) on the east. In SOUTH AMERICA we have the great system of the *Andes* on the west ; the *Brazilian system* on the east ; and the system of *Parimè*, between the rivers Amazon and Orinoco, on the north.

Of AUSTRALASIA and its mountain-chains we know too little as yet to enable us to arrange them into groups or systems, though one main ridge in Australia, extending along the eastern coast from Torres Strait on the north to the extreme point of Tasmania on the south, would seem to indicate a sameness and continuity of geological upheaval. New Zealand, in the middle island, exhibits a high, bold range on the west, whose summits (10,000 feet) are clad with snow, and whose glens are occupied by glaciers.

As regards the *general distribution* of mountains, it has been aptly remarked by Sir John Herschel that, "In the New World we find a continuity of a vast and extremely precipitous line of very elevated mountains running from the Arctic Ocean almost to the extremity of Patagonia (a distance of 8280 statute miles), skirting along the western coast of that immense continent, closely following all its flexures in the southern half, and in the northern opening out somewhat more, it is true, but still preserving the same general character of a lofty, mountainous, western border to a vast expanse of eastern lowlands ; and, throughout the whole of this border, we perceive a most distinct and unmistakable tendency to a system of double or triple ridges, nearly or exactly parallel, not here and there for short distances, but extending for hundreds of miles in succession, and resumed again and again when interrupted. In the Old World, on the other hand, we find

no single, well-defined, continuous chain running throughout, much less following the coast-line, but a broad belt of mountainous country traversing the whole mass of land in a general direction, and carried through the heart of the continents, from the extremity of Europe and North Africa across to the western shores of the Pacific. In the European portion of this system, linear prolongation, except in the Pyrenees, is very far from distinctly indicated. On the contrary, divarication and embranchment are there the dominant features, as they are especially so in the north-western region of Asia; and it requires some determination in tracing connections to follow out a leading line through the Pyrenees, the higher Alps, the Caucasus, and the mountains of Elbrouz, through the Hindu Koh, up to the great system of Asiatic mountains which enclose the plateau of Thibet. Neither is the principle of parallel association carried out with anything like the same precision and sequence in the old as in the new continent. Along the Caucasian and Elbrouz range, and as far as the termination of the Hindu Koh, this principle is pretty clearly maintained; but from the point in Little Thibet where this last-mentioned system forks out into the two great chains of the Himalaya and Kuen Lun which enclose the table-land of Thibet proper, a greater degree of confusion and interlacement prevails, and beyond the termination of these ranges in Assam and on the Chinese frontier, the mountain-system of China and south-western Asia spreads out like an immense fan; in some of whose ranges a high degree of parallelism is preserved among contiguous members, while in others the branching character prevails quite as conspicuously."

58. As mountain-systems exercise very decided influences on the natural history of the globe, and as they generally appear in ranges consisting either of one central chain with branches or spurs running off at right angles, or of several chains running less or more parallel to each other, various theories have been advanced to account for their upheaval, their parallelism, and their geographical connections. Thus, as their central masses were formerly supposed to consist essentially of igneous rocks which have been protruded from below, and as this protruding force must have acted along the line of least resistance in the crust, the question arises, What is the determining cause of these directions? The French geologist, Elie de Beaumont, attempted to show that every recognisable mountain-system occupies a fraction of a great circle of the globe—a cleft or fissure in the earth-crust being supposed to be more easily made in that direction than in any other; while he further endeavoured to demonstrate that ranges of the same

age are parallel to each other, even when in opposite hemispheres. Professor Hopkins of Cambridge, treating the subject from a mathematical point of view, was the first to show that when the upheaving forces in the earth's crust act upon a single point, the lines of upheaval must radiate from that point; hence the supposed origin of lofty central mountains with diverging spurs. He further proved that when the expansive force acts uniformly over a wide area, the lines of greatest tension and upheaval must lie in the direction either of the length or breadth of that area, and that if the crust yields in more places than one, the fissures must necessarily be parallel. The more extended studies made of late years of the great mountain-ranges of the earth, have, however, made evident that their central parts are composed, not exclusively of igneous rocks, as formerly imagined, but almost wholly of aqueous strata greatly folded and compressed; the amount of compression being most intense along the axis of the ridge, and dying out towards the plains on both sides. This has led Professor Dana of Yale, and others, to refer the origin of all the grander mountain-chains to the elevation caused by the enormous lateral pressures developed in the unequal contraction and sinking down of the cooling earth-crust over its supposed internal molten mass. Each broad subsiding area, as it descends towards the centre, occupies of necessity a less superficial space than before, and presses against the neighbouring areas with irresistible force, crushing and crumpling together the strata along the lines of contact, and forcing them upwards in a long mountain-chain—a mountain-ridge of ten or twenty thousand feet being a mere wrinkle, as it were, upon the surface of a globe nearly 8000 miles in diameter. Of course, any original parallelism or uniformity of system has been considerably obscured, if not modified, by subsequent geological changes; and it must also be remembered that, whatever may give the initial direction and mass to a mountain-range, its present features—its peaks and precipices, its glens and gorges, its slopes and counter-slopes—are the effects of erosion, the results of the degrading action of rains and frosts, of streams and glaciers, continued throughout countless ages, all wearing and wasting, scooping and gouging, with effects that are ever varied and modified locally, according to the hardness or softness of the rocks of which the mountain-range is composed.

European Systems.

59. Accepting such generalisations as initiatory steps towards the explanation of one of the most important problems connected with the history of our planet, we may now advert to the character of

the *mountain chains* or *ranges* of which the preceding systems are respectively composed. Under the *British system* are embraced the Northern or Ross-shire range, the Grampians, the Cheviots, the Cumbrian or Cumberland mountains, the Cambrian or Welsh, the Devonian, and the Hibernian or Irish, all having less or more a south-west and north-east strike, and all formed of strata, belonging to the earlier or primary geological periods. Their geological structure confers on them considerable boldness and diversity of scenery, though their minor elevation prevents that massive grandeur and ruggedness so often displayed by loftier ranges. None of them rise to the height of perpetual congelation (about 5000 feet for the centre of the British Islands); but in an insular and northern position such as that they occupy, their cold, heath-clad, inhospitable summits exercise a decided influence alike on climate, scenery, and natural productions. Arranging them in tabular order, with their culminating heights or points of highest elevation, they appear as follows:—

Northern or Ross-shire range, Ben Attow, . . .	4000 feet.
Grampians, Ben Nevis, ...	4406 „
Cheviots, ...	2600 „
Pennine chain, Pen-y-Gant, ...	2500 „
Cumbrian or Cumberland range, Scaw Fell, . .	3166 „
Cambrian or Welsh mountains, Snowdon, . .	3571 „
Devonian range, Dartmoor, ...	1800 „
Hibernian mountains, Macgillicuddy's Reeks, .	3400 „

60. The *Iberian* or *Hesperian system* embraces the Pyrenees, Cantabrian mountains, Mountains of Toledo, Sierra Morena, Sierra Nevada, and other associated elevations that give character to the rocky table-land and peninsula of Spain. Loftier in their altitude, and more extensive in their ranges, than the British system, they exercise a still more decided influence on the external condition of their region. Ranging chiefly in an east and west direction, consisting of rocks of primary and secondary formation, rising, in many parts, above the line of perpetual snow (which ascends from 8000 feet in the Pyrenees to 11,000 feet in the Sierra Nevada), and being intersected by numerous deep defiles and narrow glens, by circular valleys (*cirques*) and rocky passes, they create great diversity of scenery, climate, and production, and are of themselves the frequent storehouses of the minerals and metals. Arranged in tabular form, with their culminating points, they are as follows:—

Pyrenees, Maladetta, ...	11,168 feet.
Cantabrian Mountains, S. Gredos, ...	10,552 „
Mountains of Toledo, S. Guadalupe, ...	5,110 „
Sierra Morena, Aracena, ...	5,550 „
Sierra Nevada, Mulhacen, ...	11,687 „

61. The *Sardo-Corsican system*, as its name implies, is confined to the islands of Sardinia and Corsica, and extends from Cape Jeulada in the former, to Cape Corso in the latter. It is a high, rugged, and irregular range, attaining its culminating point in Monte Rotondo, in Corsica, which rises to the height of 8767 feet—an elevation closely bordering on the line of perpetual snow, which in that latitude ascends to 9000 feet. In its geological bearings it is evidently connected with the Alpine development, and ought, properly speaking, to be regarded as a mere outlier of that gigantic but imperfectly defined system.

62. Under the *Alpine system* are usually comprehended the whole of those extensive and lofty mountains which, from Switzerland as a centre, ramify in ranges more or less persistent, and confer on southern Europe one of its most marked and peculiar features. These ranges have many minor subdivisions, but for our present purpose it will be enough to range them into the (1) Western and (2) Eastern Alps, which, under several local names (the Maritime, Cottian, Graian, Pennine, Helvetian, Bernese, Rhætian, Carnic, Noric, and other Alps), extend in a north-east direction from the shores of the Mediterranean to the tableland of Bohemia; the (3) Gallo-Francian mountains, including the Jura, Vosges, and other contiguous French ranges; (4) the Apennines, traversing the entire length of the Italian peninsula, and terminating in the still active volcano of Etna; (5) the Slavo-Hellenic ranges, lying between the shores of the Adriatic and the plain of the Danube, and which stretch eastward into the Balkan chain on the one hand, and southward into the Pindus chain on the other; and (6) the long range of the Carpathians, Krapacks, or Hercynian Mountains, which rise between the plain of the Danube and the great plain of Europe, and mark the northern limits of the system. The strata upheaved in this grand Alpine system are of various geological ages, ranging from the crystalline schists of the Western Alps, through the secondary limestones and altered shales of the Jura, down to the tertiary beds of the sub-Apennines and the recent lavas and scorix of Vesuvius and Etna. Connected with the older range of the Pyrenees on the west, and with the still active craters of Vesuvius, Etna, and the Lipari Islands on the east, the Alpine system may be said to have been on the increase from Permian times to the present moment. Even since the tertiary period, to much of the Auvergne, Apennine, and Hellenic ranges, and to the Alps themselves, an additional altitude has been given of not less, perhaps, than 4000 or 5000 feet. Being of different geological structures and altitudes, the different members of the Alpine system present great diver-

sity of character and aspect. Rising in many places above the snow-line, which sinks from 9000 feet in the Alps to 6000 feet in the Carpathians, they are rugged with peak and precipice, glacier and narrow gorge, as in the Helvetian Alps; swelling and sloping in outline, as in the Apennines; crateriform and terraced, as in the hills of Auvergne; rocky and precipitous, as in the Balkan and Pindus ranges; or rich in minerals, as in the mountains of Transylvania. With the exception of the plains of Bavaria and Bohemia, which lie on the very outskirts of the system, there are no table-lands, in the proper sense of the term, connected with the development of the Alpine ranges—the whole being a true typical mountain-series of ridge and valley, peak and pass, beetling precipice and rugged ravine. Many of the “passes” are practicable even at great elevations—that of the Col du Geant being 11,146 feet, and the Adler not less than 12,461. Subjoined are the component ranges of the system, with their culminations or points of highest elevation :—

Western Alps, Mount Pelvoux, . . .	14,108 feet.
Eastern Alps, Mount Blanc, . . .	15,781 ”
„ Mount Rosa, . . .	15,217 ”
„ Matterhorn, . . .	14,780 ”
„ Finsteraarhorn, . . .	14,026 ”
„ Jungfrau, . . .	13,671 ”
Gallo-Francian, Mount Mollecon, . . .	6,588 ”
Apennines, Gran Sasso, . . .	9,493 ”
Slavic range, Mount Kom, . . .	9,000 ”
Hellenic range, Olympus, . . .	9,749 ”
Balkan range, Tchar Dag, . . .	9,700 ”
Carpathians, Tatra, . . .	8,685 ”

63. The *Scandinavian system*, as the name implies, embraces the whole of the mountainous highland of Norway and Sweden, and extends in a north-eastern direction from the Naze to the North Cape, a distance of 1160 miles. It consists of a series of plateaux, or high open fields (*Fjelds*), rather than of a continuous mountain-ridge—these elevations narrowing from a breadth of 200 miles in the south to 60 or 40 in the north, and being distinguished as the Hardaangar or Langefeld in the south, the Dovrefeld in the middle, and the Kiolen Mountains in the north. Intersected by numerous ravines and gorges, the range presents a steep face and rugged coast-line of fiords and cliffs to the North Sea on the west, and a terraciform slope downwards through Sweden to the shores of the Baltic on the east. A great portion of the range rises above the limit of perpetual snow (which ascends from 2400 feet at the North Cape to 5000 feet in the Langefeld), but beneath this limit the mountain-sides are covered with straggling forests of birch and pine. Geologically speaking,

the whole system is formed of primary rocks—granitic, crystalline, and palæozoic rocks composing the mass, which is abundantly traversed by metalliferous veins of iron, copper, lead, zinc, and antimony. Though the general elevation of the irregular table-lands seldom exceeds 5000 feet, the culminating points rise to a considerable altitude ; thus—

Langefeld, Skegstol-tend,	.	.	.	8670 feet.
Dovrefeld, Sneehatten,	.	.	.	7620 „
Kiolen, Sulitelma,	.	.	.	6200 „

According to Principal J. D. Forbes, the Scandinavian mountains do not constitute either unbroken chains rising from the low grounds and forming a ridge, nor are they a series of distinct detached elevations, but, in the southern division of the country especially, they form *plateaux* or table-lands of great breadth, and generally more or less connected together, though occasionally separated by deep but always narrow valleys. These wonderful expanses of mountains are often so level, that upon what may almost be called their *summits* a coach and four might be driven along or across them for many miles, did roads exist, and across which the eye wanders for immense distances, overlooking entirely the valleys, which are concealed by their narrowness, and interrupted only by undulations of ground, or by small mountains which rise here and there with comparatively little picturesque effect above the general level. These table-topped mountains are the *Fields*, or more properly *Fjelds*, of Norway, which in their less interrupted or more elevated parts have acquired specific names.

64. The *Sarmatian system* (from the ancient Sarmatia or Poland) is meant by geographers to embrace that extensive swell of country which stretchès diagonally through Russia from the plain of Poland to the flanks of the Uralian Mountains, and which forms the great watershed of northern Europe, turning the waters of the Vistula, Duna, Dwina, and Petchora to the Baltic and White Seas ; and those of the Volga, Don, and Dnieper to the Caspian and Black Seas. There are no mountains throughout its extent, the Valdai Hills attaining an elevation of only 1100 feet ; and it is chiefly of geographical importance as a great and continuous watershed of gently swelling upland.

65. Under the *Uralian system* geographers embrace the well-defined range of the Ural Mountains, which form the natural boundary between Europe and Asia, and the watershed between the extensive basins of the Volga and Obi. The range, being transverse to the usual strike of the Old World mountains, runs in a true meridional direction for a distance of more than 1600 miles, and consists of round-backed, plateau-shaped masses of very

moderate elevation generally not exceeding 2000 feet, and culminating in a few points only at upwards of 5000 feet. The range is a truly mono-linear or mono-axial one, and consists of an axis of igneous rocks, flanked by crystalline schists and the older palæozoic formations, and is rich in the precious minerals and metals—gold, platinum, iridium, copper (malachite or the green carbonate), and diamonds, being among its geological treasures. Its culminating points are—Toll-pors, 5542 feet, Konjak Ofski, 5397 feet, and Obdorsk, 5286 feet.

66. The *Caucasian system*, which forms another part of the boundary between Europe and Asia, extends in one immense chain of 750 miles from the Black Sea to the Caspian, and separates the basins of the Kuban and Terek on the north, from those of the Kur and Rioni on the south. The range is a massive one, varying from 80 to 120 miles in width, full of glens and mountain-fastnesses, and rises in many places above the snow-line, which there attains to the altitude of 11,000 feet. Comparatively little is known of its geological features, though from the reported abundance of metalliferous veins portions must consist of the older formations, while in the south and east there are abundant evidences of recent volcanic activity. The culminating point is Mount Elburz, near the centre of the chain, its height being 18,493 feet, or 2712 feet higher than Mount Blanc; and, being on the European side, is thus the highest point of the Continent. Several other points rise far above the snow-line, among which may be mentioned Kasbek, 16,532 feet, and Savalan, 15,750 feet.

Asiatic Systems.

67. Turning next to Asia, which is the main headquarters of mountains and mountain-chains in the Old World, as well as the region of highest elevation on the globe, we may begin with the *Western system*, under which is comprised those more or less associated ranges that lie between the Levant and Black Sea on the west, and the Indus on the east, and which give feature and character to the contiguous highlands of Asia Minor, Persia, Afghanistan, and Beloochistan. Among these may be noticed the Taurus and Anti-Taurus, whose hilly and irregular ranges encircle the table-land of Asiatic Turkey, and whose culminating point is Mount Argish, attaining an elevation of not less than 13,000 feet. A considerable portion of these ranges is above the snow-line, and though the table-land they support is on the whole bleak and humid, their own slopes are often intersected by valleys of great beauty and fertility. Closely connected with them, topo-

graphically as well as geologically, is the Lebanon range, which, proceeding transversely from the Taurus, stretches southward along the Syrian coast to Mount Hermon, nearly 10,000 feet high, and thence through Palestine to the peninsula of Sinai, where Horeb, 8593 feet, and Sinai, 7497 feet, terminate the chain. In the northern portion of the chain the loftier heights are covered with perpetual snow, while the lower slopes are wooded and fertile; but in the southern portion, the mountains, though lower, are abrupt, rocky, and arid. Also intimately associated with the Taurus and Anti-Taurus, and in fact but prolongations of the same ranges, are the mountains of Armenia, which trend eastward in the Elburz, and southward into the Zugros and hills of Kurdistan. They form a series of broad-shouldered mountains, with lofty intervening valleys, and culminate in the steep-sided, snow-covered cone of Ararat, whose height has been variously given at 16,916 and 17,210 feet. The Elburz range—a continuation, as it were, of the Armenian and Taurus mountains—skirts the southern shores of the Caspian, where it attains, in the slumbering volcano of Demavend, an altitude of 18,469 feet, and thence stretches eastward, with less defined elevation, into the high grounds of Tartary and the chain of the Hindoo Koosh. This last-mentioned range, the Hindoo Koosh or Hindoo Koh, separates Affghanistan and the Punjaub from Independent Tartary, and forms the watershed between the Amoo and the Indus. Its maximum elevation is about 20,000 feet, and, trending eastward in broad massive ridges into the Kuen-lun and Himalayas, it may be regarded as the commencement of the great central system of the Asiatic continent. Such are the principal members of the *Western mountain-system* of Asia, which are all intimately connected with the first plateau stage of that continent. In the main, they run in east and west directions, though sending out several southern spurs, as the Lebanon, Kurdistan, and Beloochistan hills. They are largely of secondary and tertiary age; and though intersected by minor valleys, they fade away rather into high arid table-lands than alternate with river-plains of corresponding dimensions—those of the Euphrates and Jordan being the only alluvial plains of any importance. The following are among the highest points of the system:—

Hindoo Koosh, summit,	.	.	.	20,232 feet.
Elburz range, Demavend,	.	.	.	14,675 „
Armenian mountains, Ararat,	.	.	.	17,210 „
Anti-Taurus, Argisch,	.	.	.	13,197 „
Taurus, summit,	.	.	.	9,800 „
Lebanon, Jebel-el-Makmel,	.	.	.	12,000? „
„ Hermon,	.	.	.	10,000 „

68. Closely connected with, and following the western, is the great *South-eastern system of Asia*, extending from the knot of the Bolor Tagh to the extremities of Malay and Cambodia, and comprising not only the highest mountains in that continent, but the highest known elevation on the surface of the globe. Pre-eminent in the system stands the chain of the Himalaya ("abode of snow"), stretching in a somewhat south-easterly direction between the basin of the Ganges and the upper basin of the Brahmapootra, forming the northern and all but impassable boundary of India, and constituting the southern buttress of the great central table-land. The range extends about 1500 miles in length; varies from 150 to 350 miles in breadth; has a mean elevation, according to Humboldt, of 15,670 feet; and rises in many points (upwards of forty, it is said) to an altitude of 23,000 feet—the three highest peaks being Everest, Gahurishank, Chingopamari, or Deodunga, 29,002 feet; Kinchinjunga, 28,156 feet; and Dwhalagiri, 27,826 feet. The snow-line rises, according to position in the range, from 13,000 feet on the south side, to 16,000 feet on the north side, where the air is drier; and a large portion being thus perpetually covered with ice and snow, the Himalayas present every possible feature of mountain grandeur—peak and precipice, gorge and glacier, rugged ravine and headlong waterfall. Geologically speaking, the higher and central portions of the Himalaya, with a few exceptions, consist of granitic and metamorphic rocks; their flanks exhibit in many places palæozoic and secondary strata; and at elevations of 3000 and 4000 feet along their bases—in the Siwalik or sub-Himalayan hills—occur limestones and gravels replete with the remains of tertiary mammals. Indeed, the whole chain, as well as a large portion of the Asiatic continent, has been elevated many thousand feet since the tertiary epoch—tertiary fossils being found on the terraces, passes, and plateaux, at elevations of 6000, 10,000, and even 17,000 feet above the present sea-level. Abruptly separated from the Himalaya by the transverse valley of the lower Brahmapootra, but still holding less or more in the same axial direction, are the mountains of Assam, a congeries of great irregular heights, partaking of much of the Himalayan character, but as yet very partially known or explored. Beyond the mountains of Assam, but still in continuation of the system, lie the well-defined ranges of northern Burmah (the Kakhyeen Hills), Siam, and Cochin-China—all trending in a southerly direction, separated by low-lying river-valleys, and giving contour and character to the Cambodian and Malayan peninsulas. Little is known of these peninsular mountain-ranges, or of their elevations; but, well watered and approaching the

equator, we know that to great elevations they are covered with impenetrable forest-growth. Outlying the system, but still connected with the same area, are the mountains which give figure and relief to the peninsula of Hindostan. These are the Vindhya chain, which forms, as it were, the northern barrier of the Deccan; the Western Ghauts, that guard it on the west; and the Eastern Ghauts, that support it on the east,—the two latter chains converging into the loftier heights of the Nilgherri Hills in the south. The plateaux of the Deccan rise step by step southward from 1500 or 2000 feet in Nizam, to 4000 feet in Mysore; the Western Ghauts ascend from 2000 to 7000 feet; the Eastern from 2000 to 3000 feet; and the Nilgherries in many points from 6000 to 7000 feet—attaining their culmination in the peak of Dodabetta, 8760 feet high. Tabulating the south-eastern system, with its culminating points, we have,—

Himalaya, Everest,	.	.	.	.	29,002 feet.
„ Kinchinjunga,	.	.	.	.	28,156 „
„ Dwhalagiri,	.	.	.	.	27,826 „
„ Nandadevi,	.	.	.	.	25,749 „
Nilgherri, Dodabetta,	.	.	.	.	8,760 „
Western Ghauts, Tandiamole,	.	.	.	.	5,781 „
„ „ Bonasson,	.	.	.	.	7,000 „
Eastern Ghauts,	.	.	.	.	3,000 „

69. Starting from the same central knot of the Bolar Mountains and extending eastward to the Pacific, we have next the *Eastern system of Asia*—a series of vast and partially known ranges, associated with high desert table-lands in Tibet and upper Tartary, and alternating with alluvial plains in the eastern districts of China. The system commences with the chain of the Kuen-lun, rising between the valleys of the upper Indus and Brahmapootra on the south, and those of the Amoo and Yarkand on the north, and extending in an easterly direction for nearly 1200 miles, at an altitude of 15,000 to 18,000 feet. Lying as it does in the same line with the Elburz on the west, and prolonged into the Pe-ling on the east, the whole looks like one great range, and is, no doubt, geologically dependent on the same axial elevation. As the Himalaya formed the southern, so the Kuen-lun forms the northern wall of the plateau of Tibet, the loftiest inhabited region in the world, having a mean elevation of 15,000 feet above the sea, and rising from 12,000 feet in its western area to full 17,000 feet in the east. Holding eastward, as we have stated, into the main ridge of the Pe-ling Mountains, that rise between the basins of the Yang-tse-Kiang and Hoang-Ho, the system at the same time diverges, fan-like, into the Yun-ling

chain, between Tibet and China; the Nan-ling, between the basins of the Yang-tse-Kiang and Canton River; and the conjunct chains of the Ala-shan, In-shan, and Khingan, that trend in a north-easterly course and form the southern wall of the great Mongolian desert. Altogether, the Eastern system is little known to geographers, either as regards the altitude of its mountain-chains, their physical features, their geological structure, or the minerals and metals they contain.

70. Commencing, in like manner, with the central knot of the Bolor, and stretching away in broad, more or less parallel lines, to Kamtchatka and Behring Strait, occurs the *Northern system of Asia*, flanked by the arid deserts of Tartary and Mongolia on the south, and descending by gradual stages to the great plain of Siberia on the north. The system embraces the Thian-shan, or Celestial Mountains, ranging in an easterly direction for nearly 1400 miles, ascending in greater portion above the line of perpetual snow, but comparatively free from glaciers on account of the dryness of the air, and exhibiting throughout a number of volcanic cones, some of which, like Pe-shan and Ho-tscheou, are said by some authorities to be still active at elevations of more than 10,000 feet. In north-easterly continuation we have next the Altai Mountains, comprising several parallel ridges (the Tang-nu, Ulam-gom, and Dzungari, the Daurian, Yablonoi, and other little known ranges—all rising between Siberia and Mongolia, and separating the basin of the Amoor from those of the Yenesei and Lena. These closely associated ranges are said to have a mean elevation of from 5000 to 8000 feet; embrace a few active and many extinct volcanoes; rise high in numerous points above the snow-line, which is there about 6000 feet; and culminate occasionally in peaks of 10,000 and 11,000 feet. The highest point is the peak called Bielukha, which is said to have an elevation of about 11,000 feet. Like other clustering ridges, the Altai and Daurian Mountains enclose a number of lakes, which find an outlet by narrow cross valleys, through terrace by terrace downwards to the larger rivers of Siberia. Still northward and eastward, but ramifying more irregularly, occur the Aldau, Stannovoi, and other chains that terminate in the volcanic system of Kamtchatka. These ranges are for the most part covered with snow (the snow-line sinking to 4500 and 4000 feet in Eastern Siberia), and contain numerous volcanic cones which, like Schiwelutch, 10,548 feet, and Klientschewska, 16,131 feet, are still in active eruption. Indeed, the whole system is more or less volcanic—active cones, dormant craters, hot springs, gas-springs, and other kindred phenomena, marking the broad line of mountainous elevation that

extends from Demavend on the Caspian to Klientschewska in Kamtchatka.

African Systems.

71. Of the African continent, to which we next turn, our knowledge is yet too limited to enable us to do more than merely advert to some of the more prominent mountain-regions, as likely embracing within their limits the elements of separate and independent systems. Our knowledge of Africa, however, is every year becoming more precise, and in no feature is it more interesting than that which reveals an interior of mountain and plain, river and lake, instead of, as at one time supposed, an arid and monotonous desert. In the extreme north we have the *Atlas system*, between the Mediterranean seaboard and the Sahara, and extending from Tripoli on the east to the Atlantic on the west. Geologically, it is evidently connected with the systems of southern Europe, and consists of three or four parallel ranges, which ascend stage by stage from the basin of the Mediterranean, and increase in altitude from east to west—being about 2000 feet in Tripoli, 4500 in Tunis, 7700 in Algeria; while in Morocco, Mount Miltsin, or Atlas, ascends to 11,400 feet, and Jebel Tedla to 13,000 feet, or above the line of perpetual congelation. Several secondary spurs proceed from the main ranges—one northward, terminating in Cape Spartel at the Straits of Gibraltar, and several others southward into the desert plateaux of the Sahara.

72. Next in importance is the *Abyssinian system*, connected with and forming the lofty table-land (Amhara) of Abyssinia and upper Ethiopia—the gathering-ground of the Atbara and Blue Nile. This plateau, which is 8000 feet above the sea-level, is supported and traversed by several clustering ranges of great elevation, and in many points above the line of perpetual snow, which is there about 14,000 feet. The two most persistent chains, under the names of the Samen and Taranta, strike in a northerly direction between the upper forks of the Nile and the Red Sea, and, skirting the shores of the latter, are prolonged into the lower hills of Egypt, which at the Gulf of Suez connect themselves with Sinai and the mountains of Syria. The culminating points in the Samen or upper range are Ras Detschen, 15,968 feet; Buahat, 15,000 feet; Abba Jarrat, 14,707 feet; and Umbattai and Beyeda, each 12,000 feet. In the Taranta or lower range, the heights descend from 9000 to 6000 and 5000 feet towards the Red Sea and the plain of Egypt. The system consists largely of granites, syenites, porphyries, and crystalline schists, and exhibits, in the higher range, that

bold and rugged character distinctive of these formations ; while in the lower many of the hills are curiously capped by basaltic outflows, whose steep and disintegrating cliffs give to them the aspect and character of impregnable hill-forts.

73. In Western Africa the mountains are by no means well known, but under the *Guinea system* are usually embraced the Kong and Cameroon Mountains—the former rising between the Gulf of Guinea and the Niger, and generally averaging from 1200 to 3000 feet (Soracte, 1278, and Mount Ramel, 3200 feet); and the latter stretching eastward and unknown into the centre of the continent, and rising in many points to elevations of 4000, 6000, 9000, and even 13,700 feet. From the Cameroons, southward to Damara Land, the seaboard rises in terraces, backed by several ranges, of which very little is known ; though the Campleda chain is said to attain an elevation of from 12,000 to 14,000 feet ; the Mozamba, from 8000 to 10,000 feet ; and the Omatako Berg, from 8000 to 9000 feet.

74. In Southern Africa the surface is occupied by a series of sandstone plateaux, resting on, and intersected by, granitic rocks, rather than characterised by a series of well-defined mountain-chains—these flats (*karoos*) rising step by step, from south to north, at elevations of 2000, 4000, and 6000 feet above the sea-level. The steps of this ascent consist of rocky walls and flat-topped mountains, ranging in an east and west direction, and intersected by narrow defiles (*kloofs*), which form the only means of passage from terrace to terrace ; and these mountains (*bergs*) may, for the sake of reference, be denominated the *Cape system*. It consists, 1st, of the Zwellendam range, about 20 miles inland from the Cape coast, and stretching for nearly 200 miles in length, and attaining, in Table Mountain, an elevation of 3550 feet ; 2d, the Zwarte or Black range, about 30 miles further north, and separated from the Zwellendam by the Kannaland Karoo ; and, 3d, the northern chain, consisting of the Roggeveld, Nieuwveld, Winter Mountains, Sneeuwveld, Wittebergen, and other contiguous ranges, separated from the Zwarte hills by the great Karoo, and attaining heights of 4000, 6000, and even 8500 feet, as in the Compass Berg in the Sneeuwveld or Snowy range.

75. From this point begins what may be termed the *Eastern system*, consisting of the Drakenberg or Quotlamba Mountains (10,000 feet), the Lupata Mountains (8000 or 10,000 feet), and other ranges that hold northward in parallel lines and increasing altitudes towards the equator, where several of the higher peaks (Kenia and Kilmandjaro, 18,000 and 18,700 feet) are said to be covered with perpetual snow, and overlook the sources of the

Nile and Congo. Others of somewhat inferior elevations, such as the ranges of Balegga and Lokinga, and the peak of Mfumbiro (10,000), are scattered irregularly throughout the upland lake-region between the Zambesi and the equator.

Australasian and Polynesian Systems.

76. Of Australia and its mountain-chains it has been already stated (par. 57) that we know too little to enable us to arrange them into groups and systems, though one main ridge, extending along the eastern coast, from Torres Straits on the north to the extreme point of Tasmania on the south, would seem to indicate a sameness and continuity of geological upheaval. This chain is extremely rugged and inaccessible on the coast side, but slopes gradually towards the interior, and seldom exceeds 5000 feet in elevation—Mount Kosciusko, 6500 feet, and Sea-View, 6000 feet, in Australia, and Mount Humboldt, 5502 feet, in Tasmania, being the highest known points of elevation.

New Zealand contains one mountain-chain of considerable elevation—ranging north and south, and about 30 miles from the western coast. This great backbone is full of peaks and passes—the former often exceeding 10,000 feet in height, and the latter said to be practicable at elevations of 6000 and 8000 feet. Glaciers, according to Dr Hector, of the New Zealand Geological Survey, occupy many of the higher valleys, and send their ice-streams fully 13 miles down into the lower country. The culminating points of the system are Mount Cook, 13,200 feet high, Mount Ruapehu, 9195, and Mount Egmont, 8270. The mountains on the eastern side are chiefly volcanic—Tongoriro being 6200 feet in height, and often in full activity.

Of the mountains that occur in the many islands of the Pacific and Indian Archipelago, it may be remarked that they are chiefly active volcanoes, and though often occurring in obvious linear connections, and of great altitudes (6000, 10,000, and 14,000 feet), they are merely to be regarded as chains in embryo, and as the rudiments of systems yet to be elaborated. The Aleutian Isles, the Japan and Kurile Isles, the Philippine and Molucca Isles, the islands of India and Australasia, the Sandwich Islands, the Society Isles, and Marquesas—all form volcanic groups and series of evident central and axial connections; and their results on the geography of future ages cannot fail to be as marked and decided as the influences of the Andes or Alps are on the physical features of the present day. Their highest known points are :—Mauna

Loa in the Sandwich Islands (13,760 feet); Fusi-yama in Japan (14,177 feet); Semeroe in Java (12,150 feet); and Indrapura in Sumatra (12,140 feet).

American Systems.

77. Having reviewed the mountain-systems of the Old World, we now turn to those of the New, where the arrangements are altogether on a simpler and more uniform plan. In North America we have first the *Eastern, Appalachian, or Atlantic system*, so called from its general proximity and parallelism to the Atlantic seaboard. It separates the waters that flow eastward into the Atlantic from those that flow westward into the basins of the Mississippi and St Lawrence: and though trending in one continuous direction from the St Lawrence to the Gulf States, may be said to consist of two divisions—the Blue Ridge, Shenandoah Ridge, and Alleghany on the south, and the Green and White Mountains on the north—separated from each other by the narrow cross-valley of the Hudson. In length the system is nearly 2000 miles, has an average breadth of 100 or 130 miles; and though its mean altitude is only about 2500 feet, it yet ascends in Mount Washington in New Hampshire to 6428 feet, in Black Mount between Tennessee and Carolina to 6476 feet, and in Mount Katahdin in Maine to 5360 feet. In the northern section of the system, the ridges of the Notre Dame, the Green, White, and Adirondack Mountains are more or less irregular and interrupted; but in the southern, the Alleghanies consist of several closely parallel chains of great continuity, though frequently cut across by ravines and river-courses. Geologically, the system consists chiefly of the older palæozoic rocks, flanked on both sides by an extensive development of carboniferous strata; and its eastern slopes comprise some of the finest and most diversified country in the American Union. Separated from the preceding system by the valley of the St Lawrence, but still trending in the same general direction to the northern shores of Labrador, occur the Wotschish and Mealy Mountains, which, though seldom exceeding 1400 or 1600 feet in height, are yet, from their boreal position, for the most part covered with perpetual snow. The following are the culminating points of this Eastern or Atlantic system:—

Mount Washington, New Hampshire,	.	.	6428 feet.
Black Mount, Carolina,	.	.	6476 „
Mount Jefferson, Alleghanies,	.	.	5860 „
High Peak, Adirondack Mountains,	.	.	5467 „
Katahdin, Maine,	.	.	5360 „

78. Interiorly and beyond these eastern ranges the country is one immense plain till we come to the *Western* or *Pacific system*, which, under the familiar name of the Rocky Mountains, stretches in several more or less connected ranges from the Isthmus of Panama to the shores of the Arctic Ocean. This extensive system, which after all is but the northern prolongation of the great backbone of the New World, consists of two main ranges—the Pacific or Oceanic, skirting the western seaboard from Cape Lucas in California to Cape Elizabeth in Aliaska; and the Rocky Mountains proper, extending in double and sometimes in treble chains from Panama to the Arctic shores. The former of these ranges forms the watershed between the Pacific on the west, and the Colorado, Columbia, and Colville on the east. Though continuous as one great range, it consists of several members, such as the Sierra S. Lucia and Sierra Nevada in California, whose highest points are Mount St John 8000 feet, and Mount Tsashti 14,000 feet; the Cascade range in Oregon territory, culminating in Mounts Hood and Jefferson 15,000 feet, and Mount St Helens 15,750 feet; and the Sea Alps in the north, having their highest points in Mount Fairweather 14,783, and Mount St Elias 17,900 feet. Geologically, the range is of comparatively recent origin, contains many extinct and dormant volcanoes, and evidently connects itself with the still active series of the Aliaska peninsula and the Aleutian Islands. The latter or Rocky Mountain range forms, on the other hand, the long watershed between the tertiary valleys of the Colville, Fraser, Columbia, and Colorado on the west, and the great Lake region and the plains of the Mississippi on the east. It consists, in like manner, of several members, which, though obeying the same axial direction, yet separate and converge so as to constitute a series of plateaux of varying magnitude and elevation. At the southern extremity of the range we have, *first*, the volcanic chain of Guatemala, rising in the craters of Atitlan and Agua to 12,500 and 15,000 feet; *second*, the clustering or transverse mountains of Anahuac or Southern Mexico, ascending in Orizaba and Popocatepetl to 17,337 and 17,884 feet; *third*, the Cordillera of Cohahuella and Potosi, and the Sierra Verde and Madre, which support the lofty table-land of New Mexico, and ascend in Pike's Peak and Long's Peak to 10,000 and 12,000 feet; *fourth*, the Wind River Mountains, &c., between Nebraska and Oregon, attaining, in Holy Cross, an elevation of 17,000 feet, Big Horn, 15,000 feet, Freemont's Peak, 13,568 feet; and, *lastly*, the northern and parallel ranges of the Rocky Mountains proper, which rise in Mount Hooker to 15,700 feet, and in Mount Brown to 15,970 feet. Geologically, the whole of this vast range is of

ancient formation, with the exception of the volcanic mountains of Guatemala and Mexico, and these are evidently portions of the still active development of Central America and the West India Islands. Indeed, the whole of the Pacific system, with the exception of the Rocky Mountains proper, partakes less or more of the volcanic character; with this observed difference, however, that towards the north in the seaward range the igneous forces are becoming more active, while in the inland range the reverse is the case—the only section of activity being in Mexico and Central America. Among the many elevated points of the Pacific system, the following may be given as the higher and better known :—

Mount St Elias, Volcano, Aliaska,	.	.	17,900 feet.
Popocatepetl, V., Mexico,	.	.	17,884 „
Orizaba, V., Do.,	.	.	17,337 „
Holy Cross, Rocky Mountains,	.	.	17,000 „
Mount Brown, Do.,	.	.	15,970 „
Mount Hooker, Do.,	.	.	15,700 „
Mount St Helens, Cascade Range,	.	.	15,750 „
Mount Hood, Do.,	.	.	15,500 „
Mount Shasta, V., Do.,	.	.	14,400 „
Mount Fairweather, Aliaska,	.	.	14,783 „

79. In South America the pre-eminent system is that of the *Andes*, which extends along the Pacific seaboard from Tierra del Fuego on the south to the Isthmus of Panama on the north—there almost connecting itself with the onward prolongation of the Rocky Mountains. As a mountain-range the Andes form one of the most definite and persistent on the globe—skirting in unbroken ridges the entire Pacific shore for nearly 4500 miles in length, and varying in breadth from 40 to 350 miles. In some places the range consists of a single ridge; in other places of two or more ridges supporting lofty but narrow plateaux; and in general it presents a steep slope towards the Pacific, from which it is distant from 20 to 80 miles, while towards the east it descends by gradual stages into the broad plains of the Orinoco, Amazon, and La Plata. According to Humboldt, the mean elevation of the Andes is 11,830 feet, and the extent of surface covered by their bases not less than 531,000 square geographical miles. Geologically, the system is composed of granites, greenstones, and porphyries, piercing metamorphic schists and palæozoic strata, which are abundantly intersected by metalliferous veins. It exhibits throughout a greater number of active craters than any other mountain-chain, and in consequence is largely crowned and covered, especially on its western slopes, by vast accumulations of lava, scorix, and other volcanic products. Though presenting

one continuous axis, the range consists of several members, known by the countries in which they occur, as the Patagonian, the Chilian, the Bolivian, the Peruvian, and the Colombian Andes. The Patagonian section consists of a single range of moderate elevation, but ascending in several points (Mount Darwin, Mount Stokes, the volcanoes of Yanteles and Minchinmadiva) to 6400 and 8030 feet. As the snow-line descends in Southern Patagonia to 3000 feet, much of the range is perpetually frozen, and glaciers, unknown in other parts of the Andes, make their appearance in the higher glens and gorges. The Chilian Andes extend, in like manner, in one immense ridge; and though their mean elevation is inferior to those of Bolivia, they yet contain the giant Aconcagua—the culminating cone of the system, and the highest known point in the New World continent. The snow-line in this portion of the system rises from 8000 to 10,000 feet; and high above it, in perpetual winter, rise the lofty peaks of Aconcagua, 23,290 feet; Tupungata, 15,000 feet; and the volcanoes of Chillan and Villarica, 16,000 feet. Next in northward order occur the Bolivian Andes, rising in two parallel ranges—the Cordillera of the Coast and the Cordillera Real—and supporting between them the table-land of Desaguadero, 13,000 feet above the sea, 500 miles in length, from 30 to 40 miles wide, and enclosing Lake Titacaca at an elevation of 12,846 feet. In this, the central portion of the system, the snow-line ascends from 15,000 to 18,000 feet; and high above it, in the western range, rise Sahama, 22,000 feet; Chiquibamba, 21,000 feet; and the volcanoes Chipicani and Arequipa, 18,898 and 18,373 feet; and in the eastern range Sorate, 21,286; Illimani, 21,140; and Cochabamba, 17,000 feet. Northwards, from the Bolivian plateau, which terminates in the Knot of Cusco, the Andes open up into three parallel ridges, known as the eastern, central, and western Cordilleras of Peru—the western being the highest, and separated from the Pacific by a sandy and arid desert 120 miles in breadth. In these Cordilleras the highest points are Sasaquanca in Lima, 17,904 feet; Vilcanota, 17,525; and the Knot of Pasco, 11,800 feet. Leaving the Cordilleras of Peru, which terminate in the Knot of Loxa, we next meet in northward order the Colombian Andes, or the Andes of Quito—a lofty volcanic portion of the system, which rises in double or treble ridges, one main portion extending in the direction of Panama, and another bending north-eastward to the Caribbean Sea. In this region, much of which lies directly under the equator, the snow-line rises to 15,000 or 16,000 feet; and hence all the higher peaks and volcanoes—Chimborazo, 21,424; Cotopaxi, 19,500; Antisana, 19,132; Coyambe, 19,534; and Tolima, 18,120

feet—are covered with perpetual snow. Such are the various portions that constitute the giant system of the Andes—a system which, whether in its extent and linear continuity, its boldness and altitude, its high inhabited table-lands, its mineral riches, or its physical influences, is, even more than the Himalayas, the most remarkable on the globe. As already mentioned, the mean elevation of the Andes (according to Humboldt) is 11,830 feet; upwards of forty points rise above 14,000 feet; and at least twenty points exceed 19,000 feet. The following are the more important summits:—

Aconcagua, Volcano, Chili, . . .	23,290 feet.
Sahama, V., Peru, . . .	22,000 „
Chimborazo, Ecuador, . . .	21,424 „
Sorate, Bolivia, . . .	21,286 „
Illimani, Do., . . .	21,140 „
Chiquibamba, Do., . . .	21,000 „
Cayambe, Ecuador, . . .	19,534 „
Cotopaxi, V., Do., . . .	19,500 „
Chipicani, Peru, . . .	18,898 „
Arequipa, Do., . . .	18,373 „

80. The mountain-system next in importance in South America is that of *Brazil*, occupying the eastern portion of the continent, extending in several parallel ranges from the plains of the La Plata on the south to those of the Amazon on the north, and spreading inland for nearly 1800 miles in a broad plateau, whose mean elevation is about 3200 feet. These ranges or ridges of table-land are separated from each other by the affluents of the Amazon and the St Francisco on the one hand, and by those of the Paraguay and Parana on the other, and succeed each other—ridge and plain—with wonderful continuity. Proceeding from the Atlantic westward, we have, *first*, the Sierra Espinhaço, whose culminating heights are Itambe, 8428; Orgaos, 7700; Piedade, 5830; and Itacolumi, 5750 feet; and the Sierra do Mar, or Seamount, which attains in Morro dos Candos an elevation of 4476 feet; *second*, the Sierra Tabatinga, forking northward into the Irmaos and Sierra Mangabeiros; *third*, the Cordillera Grande, whose chief heights are from 6000 to 7000 feet; and, *lastly*, the Sierra de los Vertentes and other inferior ridges, that gradually descend into the great central plain of the continent. Geologically, the Brazilian system is eminently primary, consisting of granitic protrusions and crystalline schists rich in the precious minerals and metals; abounding, from the character of its rocks, in picturesque beauty; and from its tropical situation and minor elevation, clothed to the summits with an exuberant and varied vegetation.

81. The last and only other mountain-system in South America is that of *Parimè*, which occupies the oval tract of country lying between the Amazon and Orinoco, and forms the high ground from which descend many of the minor affluents of these gigantic rivers. This plateau, whose mean elevation is from 1600 to 2000 feet, is traversed in an east and west direction by several closely-set ridges (Sierras Acarai, Parimè, Pacaraima, Imataca, &c.), which, though of no great general elevation, yet ascend in Duida to 7149 feet, in Roraima to 7450, and in the Sierra of Merida to 15,000 feet. Like the mountains of Brazil, the system of Parimè consists essentially of crystalline schists, and has not inaptly been described as a primary island rising from the vast tertiary and recent expanses of the Orinoco and Amazon. Lying almost directly under the equator, the higher sierras are clothed with impenetrable forest-growths, while the lower grounds, according to the season, are alternately arid wastes or covered with a carpeting of the most luxuriant grasses.

82. Such are the principal mountains of the world as arranged by geographers into groups and systems. The arrangement may not in every case be a natural one—that is, the mountains composing some so-called “system” may not strictly belong to the same set of geological causations—but the arrangement, such as it is, greatly facilitates reference, and aids our comprehension of the effects produced by any mountain-group on the climate and vital economy of the region in which it is situated. The arrangement has also its topographical advantages, for little can be done in the way of correct description till the objects to be described have been arranged and classified according to some principle of similarity either in position, aspect, or origin. But whatever may be the ultimate grouping, we see in mountain chains and systems one of the most important features in the physical machinery of the globe. Rising and falling—here in easy undulations, there in steep peaks and ridges—here in abrupt crags, and there in gentle slopes—they produce a diversity of surface eminently fitted for diversity of vegetable and animal life. Presenting their high ridges to the moisture-laden currents of the atmosphere, they serve as so many points of condensation, producing clouds, mists, and showers that temper the heat in the lower regions, and refresh and nourish their vegetation. Elevated into regions of perpetual snow, in hot countries they cool the higher atmosphere, which descends in refreshing breezes to the plains below; while their snows and glaciers become perennial storehouses which, under the summer sun, yield a copious supply to the streams and

rivers of the thirsty lowlands. From their geological structure and formation they are necessarily the chief repositories of the precious minerals and metals, and even such deposits as occur in the sands and gravels of their streams have been worn and washed from their disintegrated veins. Their healthy, life-bracing heights have ever been the notable nursery-grounds of active, courageous, and independent races; while their snow-clad heights become boundaries and barriers to nations, as well as to the dispersion of plants and animals, more impassable even than the breadths and depths of the ocean. In whatever light they may be viewed,—whether as conferring diversity of surface on the land, and consequent diversity among its plants and animals—as intercepting the currents of the atmosphere and condensing its vapours into mists, rains, and snows—as fulfilling the office of gathering-grounds and storehouses to the streams and rivers—or as becoming the great natural barriers between different regions and races,—we see in mountains and mountain-ranges one of the most important parts of the machinery of the globe. Compared with the plains and valleys they may appear rough, barren, and inhospitable; but were it not for their existence, many of the existing plains would become deserts, and all the lower valleys be shorn of much of their amenity and fertility. Mountains and plains are but the complements of each other—the clouds, and rains, and snows of the one becoming the streams and rivers of the other; while the weathering and waste of the heights above become in time the fertile soils of the lowlands below.

Table-lands or Plateaux.

83. Next in importance in the vertical relief of the land are those elevated expanses known as *table-lands* and *plateaux*. A table-land, as the name suggests, is a flat elevated surface; but this idea of flatness must be received only in a comparative sense, for the surface, though plain-like on the whole, is usually diversified by minor undulations and irregularities. Being, in effect, broad mountain-masses, many of these plateaux form the *gathering-grounds* and sources of some of the noblest rivers; while their elevation confers on them a climate and a vegetable and animal life distinct from that of the surrounding lowlands. Some, however, are flat tracts of sand and shingle, partially dotted with verdure in spring and early summer, scorched and desert in summer and autumn, and shelterless, desolate wastes during winter. Whatever their superficial character, they are inseparably associ-

ated with the mountain-systems, most of these systems not rising in narrow ridges from low-lying plains, but towering aloft from the elevated floor of plateaux.

84. On turning to the map of Asia, it will be seen that all the great rivers flow north, south, east, and west from the central region, which consists in reality of a succession of lofty terraces or plateaux. First we have the table-land of Iran or Persia (including large tracts of Beloochistan, Affghanistan, and Bokhara) rising from 3000 to 4000 feet above the sea-level, upwards of 300,000 square miles in area, and presenting throughout a riverless, parched, and desolate region; next in altitude, the great sandy and rainless desert of Gobi, rising from 4000 to 6000 feet, and occupying an area of nearly 400,000 square miles; then, rising on either side of this, towards the centre, the plateaux of Dzungaria and Upper Tartary, less arid and more varied in surface; and, lastly, the still loftier plateau of Tibet, the highest inhabited region in the world, with an elevation of from 11,000 to 15,000 feet, and an area of 166,000 square miles. Besides these great central uplands there are in Asia the lateral and more isolated plateaux of the Deccan, rising from 1600 to 2000 feet in Hyderabad, to 4000 feet and upwards in Mysore; of Arabia, the sandy and arid, varying from 3000 to 6000 feet high, and spreading over an area of more than 700,000 square miles; of Armenia, 7000 feet high, supported by the Taurus and Anti-Taurus, and extending from the Dardanelles to the Caspian; and, lastly, that of Ust Urt, between the Caspian and Aral Seas. With the exception of the Deccan, and the mountain-platforms of Armenia and Tibet, the whole of these table-lands, from Arabia on the west to Gobi or Shamo (sand-desert) on the east, belong to one great belt of high, arid, and rainless country, sandy and stony in soil, desert in character, and evidently belonging to the same geological age and formation. Taking Central Arabia as typical of this broad desert belt, we find it graphically described by Mr Palgrave "as hard and stony in soil, with few sources of water rising to the surface even in winter; in spring thinly sprinkled with grass and herbs; in summer and autumn absolutely dry; and in general appearance level, monotonous, and desolate." Again, alluding to the ethnological effects of these long desert ranges of high land, it has been remarked by Humboldt, that "they separate the ancient and long-civilised races of Tibet and Hindostan from the rude nations of Northern Asia. They have also exerted a manifold influence on the changing destinies of mankind. They have inclined the population southward, impeded the intercourse of nations more than the Himalayas or the

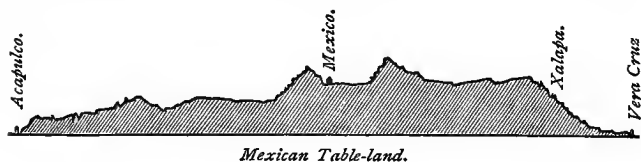
Snowy Mountains of Sirinagur and Gorka, and placed permanent limits to the progress of civilisation and refinement in a northerly direction."

85. In Europe, less elevated and more broken up by seas, we have a smaller development of table-lands, and these generally of limited area, and in the southern or higher division of the continent. The most notable is that of Castile, in Spain, having an elevation of from 2000 to 2300 feet, and traversed by hilly ridges (sierras) that give great irregularity and diversity to its surface. There is next the less defined upland of Switzerland, from 3000 to 4000 feet in elevation; and, trending north-eastward in the same direction, the lower plateaux of Bavaria and Bohemia, the latter having an elevation of only 900 or 950 feet above the sea. The so-called plateaux of Auvergne and of the Scandinavian and Balkan chains may be regarded as mere mountain-flats, too limited in extent to possess any physical feature, or to exercise any influence distinct from those of their associated ranges. In like manner, what has been termed by some geographers "the Carpathian-Uralian plateau"—that flat open region that stretches between the Carpathians and Urals—may be looked upon merely as the southern belt of the great European plain, more elevated, no doubt, than the rest, but still exhibiting more of the characters of the plain than of the upland or plateau.

86. Africa is essentially a continent of vast table-lands. The most northerly of these is the plateau of Barbary, which fringes the southern shore of the Mediterranean from Morocco to Tunis. This is succeeded to the southward by a parallel zone of depressed country, some portions of which are actually below the level of the sea. The typical region of the Sahara is formed of a series of arid uplands, stretching across the entire width of the continent from the Nile to the Atlantic, and occasionally rising to heights of 2000 or 4000 feet. South of the minor depression occupied by Lake Chad and the basin of the Niger, the surface of Southern Africa is one connected mass of elevated land. To the northward this upland region is prolonged in the plateau of Abyssinia, from 7000 to 8000 feet above the sea-level, supported and traversed by the mountain ridges, which form the gathering-ground of the Atbara and Blue Nile. The central parts of the great South African table-land are occupied by the remarkable fresh water lakes that are drained by the rivers Nile, Congo, and Zambesi, and are well-watered and fertile. Towards the line of the Orange river much of the surface is desert. To the south of that river the surface of the inland plateau descends stage by stage towards the sea coast, from an elevation of 2000 feet, in the *karoos* or ter-

race plains of Cape Colony, which are carpeted with grass during the rainy season, but parched and barren for the rest of the year.

87. In the New World the great superficial contrast is less between mountain and table-land, or plain and elevated upland, than between the gigantic mountain barrier that walls the Pacific from one extremity of the continent to the other, and the low broad plains that stretch eastward from its base towards the Atlantic. Nevertheless, in South America, the chain of the Andes presents several table-flats of vast elevation—the most remarkable being that of Bolivia, a great table-land 120,000 square miles in extent, rising from 11,000 to 12,500 feet above the sea, and early the seat of a busy and wealthy civilisation. Much also of the interior of Brazil partakes of the table-land character, having a mean elevation of 3000 feet, and traversed by the sierras (par. 80) that give feature to that fertile and tropical country. In North America, from the Russian territory on the north to Mexico on the south, there occur a series of elevated uplands, upborne, as it were, by the parallel ranges of the Rocky Mountains. One of the most remarkable of these plateaux is that comprising the highlands of Oregon, the upland region of the Colorado, and the saline desert or inland basin of Utah, whose elevation is from 4000 to 5000 feet, and the waters of which, having no outlet, form a series of salt lakes, one of which (Utah) is of considerable extent, and almost saturated with salt. Desert and inhospitable as this upland tract undoubtedly is, much of it consisting of dry, almost rainless plateau lands, that present an appearance of almost complete barrenness or desert, covered with sago-brush, it is nevertheless one of the richest regions upon the face of the globe as respects its mineral productions. It abounds in gold, silver, quicksilver, coal, and other valuable mineral products. Of late years several important towns have sprung up within its limits; it is traversed by lines of road and railway, and is the great overland highway between the Atlantic and Pacific. The most

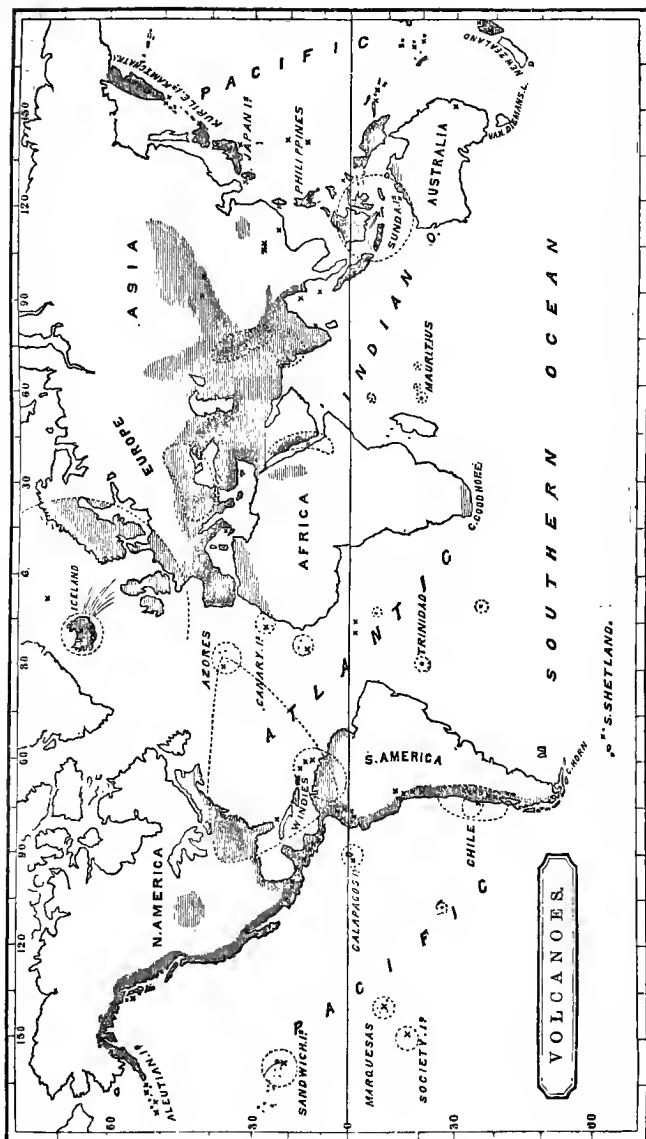


decided of the American table-lands, however, is that of Mexico, not more remarkable for its elevation than for its persistent extent. "On the eastern and western coasts," says M. Balbi, "are

low countries, from which, on journeying into the interior, you immediately begin to ascend, climbing to all appearance a succession of lofty mountains. But the whole country is thus in fact raised into the air from 4000 to 6000 and 8000 feet. This conformation of the country has most important moral and physical results; for while it gives to the table-land, on which the population is chiefly concentrated, a mild, temperate, and healthy climate, unknown in the burning and deadly tracts of low country into which a day's journey may carry the traveller, it also shuts out the former from an easy communication with the sea, and thus deprives it of a ready access to a market for its agricultural productions." The plateau of Mexico, although it lies mainly within the tropics, is blessed with a temperate and equable climate. The mean temperature at its capital is only $62\frac{1}{2}^{\circ}$ Fahr., and the difference between its summer and winter temperature, which exceeds 30° in the south of England, is only about 12° . As with the Mexican table-land, so in fact with all others of any decided elevation. A distant island in the ocean is not more separated from its contiguous continent, or more strongly marked by its own physical peculiarities, than a high mountain-walled tract raised several thousand feet into the atmosphere is characterised by a climate and vegetable and animal productions unknown in the regions that surround it.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter we have directed the student's attention to those more elevated portions of the land known as *mountains* and *table-lands*. These mountains are arranged by geographers into *chains* or *ranges*; and these ranges in turn into *groups* or *systems*, which occupy a definite area, and are, so far as may be judged from their association, of the same age of elevation. The continuity of mountain *chains* has been observed from the earliest times, and hence the antiquity of the names by which many of them are distinguished. The grander classification of these subordinate ranges into groups and systems is of recent date, and can only be regarded as yet in the light of a convenient and provisional arrangement, open to future correction and amendment when we shall have discovered the laws upon which their formation and elevation depend. There can be no question that to elevatory forces taking effect in linear or radial directions more or less connected we owe our present mountain-ranges; and to a series of such ranges that seem to be intimately associated as



** The shaded portions indicate the lines and centres of volcanic activity; the more important volcanoes being marked by a x.

regards direction or position we give the name of mountain-system. But what is the law which determines the abnormal elevations along these special lines, or within these special areas, science can as yet do little more than merely conjecture. That it is purely dynamical, depending primarily upon the contraction and subsidence of the more rapidly cooling earth-crust towards the centre, and secondarily upon upheaval acting along lines of least resistance, is the most that our present knowledge can suggest.

In the meantime, and for the sake of reference, the mountains of Europe have been arranged into the British, Iberian, Alpine, Scandinavian, Uralian, and Caucasian systems; those of Asia into the Western, South-Eastern, Eastern, and North-Eastern; and those of Africa into the Atlas, Abyssinian, Guinea, Cape, and Eastern systems. In the New World the mountains of North America are usually arranged into the Eastern or Atlantic system, and the Western or Pacific; while those of South America are distinguished as the systems of the Andes of Parimè, and of Brazil. As to the table-lands, the more important and better known in the Old World are those of Castile, Switzerland, Bavaria, and Bohemia in Europe; and of Armenia, Arabia, Persia, Tartary, Mongolia, Tibet, and the Deccan in Asia. In the New World those of Bolivia and Brazil are the most notable in South America; while in North America the only similar tracts deserving of notice are the table-land of Mexico and the desert uplands of Utah and Oregon.

In whatever form the highlands of the globe appear, whether as linear mountain-chains or as broad-spreading plateaux, they exercise most important influences on climate, and consequently on the distribution of plants and animals. In the torrid zone they afford the climate and produce of temperate regions, and in temperate zones they assume the characteristics of polar latitudes; while everywhere they are the great gathering-grounds of glacier, stream, and river—dispensing their stores to the thirsty lowlands in moderated but never-failing supplies. It must be observed, however, that mountain-chains which run in a latitudinal direction become more certain barriers to the dispersion of plants and animals, and better boundaries between nations, than those that run in a meridional course—the former severing, as it were, the zones of temperature that lie on either side, the latter connecting several zones, the warmer by their lower heights, and the colder by their greater elevations. A temperate flora or fauna may range almost from one end to the other of the Andes; whereas the life north and south of the Himalayas is separated as much as though they existed in different continents.

VII.

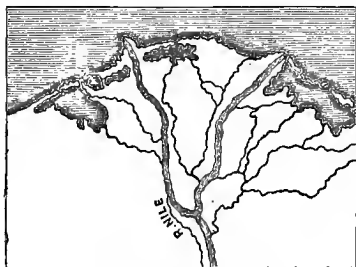
THE LAND—ITS LOWLANDS.

Plains and Deserts.

88. As the higher and more irregular portions of the earth's surface consist of mountains and table-lands, so the lower and more level consist of plains and valleys. The one set of features counterbalances, as it were, the other, and thus contributes to that variety of aspect so pleasing in the landscape, and so indispensable to diversity in its animal and vegetable productions. In a general view, mountain and plain are the direct antithesis of each other,—the former high, cold, rugged, and inaccessible—the latter low-lying, warm, fertile, and everywhere open to the dispersion of plants and animals, and to the settlement and growth of human society. Though the term *plain* is usually applied to level expanses of no great elevation, and is apt to be associated with verdure and fertility, yet several of the great plains of the world are considerably above the sea-level, and present every variety of surface, from green glassy flats to deserts of shingle and loose shifting sand. In general terms, the lowlands of the globe may be regarded as lying at elevations under 500 or 400 feet—all above those heights taking rank as “Uplands,” or “Plateaux,” or passing into the still loftier altitudes of “Mountains” and “Mountain-ranges.” As mountains are the results of crust-compression, and enormous upheavals continued through indefinite ages, and resulting in the crumpling, contortion, and, more or less, metamorphosis of their component strata, so plains and valleys are the less disturbed portions of the earth's crust, consisting of only slightly elevated, gently inclined or flat-lying strata, and in most instances represent the beds of former seas, and the silted-up sites of lakes and estuaries. Not only does their general contour convey this impression, but their soil and subsoil reveal their origin, and point to a time when large ex-

panses of sea occupied the areas of the present plains, and shallow estuaries and chains of lakes the sites of our alluvial valleys. Bearing in mind this origin, it will help to explain certain appearances of soil and surface, and enable us to account for certain distributions of plants and animals that might otherwise remain inexplicable.

89. In treating of the low level tracts of the land, the terms *plain* and *valley* are sufficiently general and well understood, and are therefore the most frequently employed in geographical description. There are others, however, which refer either to some peculiarity of surface and condition, or are of local origin, and these it may be useful at this stage to explain. Thus, the term *prairie*, though simply the French word for "meadow," is usually applied in a technical sense to the open, slightly undulating, grassy plains of North America; *llanos* are the river-plains of tropical South America, alternately covered with rank vegetation, and reduced to a desert by periodical droughts; *selvas* (Lat. *silva*, a wood), the higher tracts of the same region, densely covered with natural forest-growth; and *pampas*, the treeless but grassy plains of the Parana and La Plata. The term *steppes* is applied to the plains of northern Asia, generally covered with long rough herbage, but also partially wooded, and not unfrequently shingly and desert; *tundras* to the boggy, frozen flats of Siberia and northern Russia; and *tarai* to the belt of unwholesome jungle that lies between the plain of Hindostan and the Himalayas; *Sahara* is the long-established and familiar name for the great, arid, and



Delta of the Nile.

sandy desert of northern Africa; while *karoo* is applied to the open flats in the southern region of the same continent, which are hard and arid in the dry season, but carpeted with grasses and flowers during the periodical rains. In Britain the terms *dale* and *vale* are usually applied to minor river-plains; *marsh*, *level*, and *fen* to low partially drained re-

clamations from the sea; *strath*, in Scotland, to any wide stretch of generally flat-lying land; and *carse*, to those level alluvial flats that occur in connection with existing estuaries, and which have evidently been reclaimed from their waters either by the ordinary

process of silting, or by partial upheaval of the land. The term *delta* is also largely applied to the alluvial land formed at the mouth or rather *mouths* of a river, such as that of the Nile, which first received this name from the resemblance that the triangular space enclosed by its two main mouths bears to the Greek letter Δ or *delta*. Other terms than the above are still more local and restricted in their application, and will be better explained as they occur in the text, or in the Glossary, to which the student should make regular and systematic reference.

Plains of the Old World.

90. The principal plain in the Old World is that usually known to geographers as the *Great Northern Plain*. It may be roughly sketched as commencing with the shores of Holland on the west, and extending eastwards through Prussia, Poland, Russia, and Siberia, without any very marked interruption save the intersecting range of the Uralian Mountains. "Take away the Ural," says Carl Ritter, "and a continuous line could be drawn from Breda, near the confluence of the Meuse, Rhine, and Scheldt, across Europe and Asia, following the line of 50° N. latitude, as far as the Chinese frontier, passing over a continuous series of low, insignificant hills, heathlands, and steppes, and traversing a space estimated by Humboldt to be three times the length of the Amazon." In width, this great lowland stretches from the shores of the Arctic Ocean almost to the base of the Carpathians in Europe, and to the table-land of Persia and the flanks of the Altai Mountains in Asia—thus occupying between 4,000,000 and 5,000,000 square miles, or nearly one-third of the entire area of these continents. While it slowly rises from the Arctic shores towards the interior, as may be seen by the courses of all the great northern rivers, it may be traversed from east to west (if we except the Uralian range) without changing the level more than three or four hundred feet. In Europe this vast expanse is usually subdivided into the *Germanic plain* on the west, and the *Sarmatian plain* on the east; while in Asia it comprises the *Steppes of Kirghis, Ishim, and Baraba*, on the west, and the *Siberian plain* on the north and east. Each of these subdivisions is necessarily characterised by its own peculiarities of soil, situation, and climate, and may therefore be briefly described in detail.

The Germanic section includes the low-lying polders and morasses of Holland, and the sandy boulder-strewn plains of northern Germany and Prussia—partly under cultivation, and partly occu-

pied by extensive heaths and open pastures. Throughout, the surface is little varied, and the elevation inconsiderable, some portions of Holland being even under the tide-level, and protected by sea-walls and embankments. The Sarmatian section, on the other hand, occupying a larger area and extending over a wider range of latitude, presents a greater diversity of character, and consists, in northern Russia, of cold, swampy, and partially wooded flats; in middle Russia, of moderately temperate, fertile, richly wooded, and undulating tracts; and, in the south, of indifferent grassy steppes, river-swamps, and saline deserts. Neglecting the unimportant heights of the Valdai Hills, the maximum elevation of the middle or Moscow portion is only about 480 feet, from which the plain imperceptibly declines towards the Arctic Ocean on the one hand, and towards the Caspian and Euxine on the other.

Towards the eastern extremity of Europe, and especially after passing the Dnieper, the great plain assumes the character of, and passes by degrees into, the steppes of Kirghis, Ishim, and Baraba. These steppes present, as the name implies, wide, treeless, monotonous tracts covered with rough grass and shrubs during a brief spring season, but soon converted into arid deserts by the drought of summer, and into bleak, shelterless wastes by the storms of winter. Though they are all open, flat, and treeless, these steppes differ considerably in aspect according to the nature of the soil of which they are composed—some tracts consisting of deep black earth (*tchornozem*), clothed with shrubs and grasses—others of hard, sandy clay, and sterile—some, again, of sand, or rocky shingle, and only here and there dotted with vegetation; while others are soft, water-logged, and marshy. This description applies, however, only to the spring and early summer; for during the droughts of summer all are alike desert save round the springs and runnels of water; and during winter, which comes on in October, the whole is one exposed and inhospitable snow-waste.

The Siberian plain, as might be expected from its extent, is of a more varied character, consisting of low-lying *tundras*, or black swampy peat-mosses, of broad undulating steppes, and partially wooded uplands. In summer (from June till the middle of August) the tundras are thawed to a small depth, the steppes are scantily covered with grass and mosses, and the banks of the great rivers and uplands are green with the birch and pine; but during the long winter, frost and snow reign supreme, and the whole plain is one dreary and inhospitable wilderness. Geologically, much of the Siberian plain is of very recent origin—its frozen sands and gravels, overlaid by still increasing tundra, containing the remains

of mammoth, rhinoceros, and other animals, in wonderful preservation; and if observation be correct, is still on the increase, through that slow uprise of the land which is taking place within several areas along the shores of the Arctic Ocean.

91. The secondary plains of the Old World, though of minor extent, are not without their decided influences on the physical and vital phenomena of their respective regions. Among those in Europe may be noticed the *plain of France*, comprising the conjoined low grounds of the Seine, Loire, and Garonne, and rising in its highest parts to little more than 400 or 450 feet; the basin-shaped *plain of Hungary*, watered by the Theiss and Danube, undulating in many parts, and sometimes spoken of as the "European Pampas;" the *plain of Wallachia*, on the lower Danube, fertile but swampy; the *steppe of Astrakhan*, lying along the Caspian and Volga; and the still more restricted but locally important plains of Ireland, Denmark, Andalusia, and Lombardy.

Among the secondary plains in Asia may be noticed those of China, Hindostan, Turan, and the Euphrates. The *great river-plain of China* occupies nearly 200,000 square miles, is alluvial throughout, and still rapidly on the increase by the silting-up of the Yellow Sea, is crossed in every direction and irrigated by canals, and is the fertile seat of the oldest, most industrious, and most numerous population on the face of the globe. According to Dr Lamprey (Jour. Asiatic Society), the mud-shoals of the Yellow Sea increase about 1 foot in height in twelve or fifteen months; and, in the recollection of Chinese voyagers, mud-flats which forty years ago were indicated by beacons, are now converted into fertile rice-lands. So low is the plain in the neighbourhood of Shanghai that it has to be protected from the tides by embankments.

The *plain of Hindostan*, stretching from the base of the Himalaya to the Deccan, and from the Ganges to the Indus, is also low-lying and alluvial, abundantly fertile under irrigation, and only light and sandy in the district of "the Thur" or the lower Indus. The lowest portion of the plain is that of Bengal and along the Ganges, which, during the rainy season (June to September), is largely inundated; the most fertile and healthy is that of the Punjab, or country of the five rivers, watered by the main tributaries of the Indus; the most desert, that of the Thur, from 300 to 400 miles broad, and consisting of a hard clayey subsoil overlaid by arid shifting sands; and that portion known as the "Run of Cutch," about 7000 square miles in area, is alternately a sandy desert and covered by the waves of the sea. Enjoying every variety of climate from tropical heat and moisture to the mild

salubrity of southern Europe—partially inundated during the rainy season, verdant with luxuriant growth after the rains, and largely parched and dusty during the season of droughts, there are few regions that present such diversity of aspect as the great Indian plains, or have been so long the seat of civilised populations and shifting empire. Besides these larger Asiatic low grounds, there may be noticed the *plain or steppe of Turan*, which extends along the southern shores of Lake Aral westward to the Caspian, and is fertilised by the waters of the Syr and Amoo; and the historic *plain of Mesopotamia* (Gr. *mesos* and *potamos*, between or in the middle of the rivers), that stretches between the Euphrates and Tigris southward to the shallow waters of the Persian Gulf.

92. In Africa, with the exception of the Sahara or Great Desert, which may be described as a vast expanse of arid sands and shingle, with an occasional oasis of life and verdure, we know of no continuous plains like those of Europe and Asia, though several minor flats and deltas give diversity to its generally unbroken and monotonous seaboard. The surface of the Sahara is not, however, as at one time supposed, a uniform plain of burning and drifting sands, but presents considerable diversity both in composition and altitude. Some portions are low and flat; others sink, it is said, even below the sea-level; while many rise, in bare broad plateaux, 1000, 2000, and 3000 feet above the surrounding surface. Immense tracts are shingly and saline, others consist of loose drifting sand, occasional patches are rocky and scantily covered with thorny scrub, while at distant intervals over the arid waste some spring or surface retention of water gives birth to an *oasis* or islet of vegetation. This great desert, stretching from Morocco on the west to the valley of the Nile on the east, is prolonged, as it were, eastward and northward through Arabia, Persia, and Tartary to Mongolia, where it terminates in the equally arid and sandy desert of Shamo—the whole tract from the Sahara to Shamo pointing at once to similarity of conditions and sameness of geological origin. The minor low grounds of Africa, sufficiently known to geographers, are those on the lower courses of the Senegal and Gambia—Senegambia; the swampy and jungle-clad delta of the Niger; and the fertile periodically-inundated delta and valley of the Nile, which, for four or five thousand years, has been the classic site of industry and civilisation.

93. Respecting Australia—the only other region in the Old World sufficiently extensive to admit of plain-lands—its interior may be defined, broadly speaking, as a vast inland plain with a

very irregular surface—here scrubby and waterless, there presenting, on the contrary, grassy flats, green forests, and river-creeks. Towards the north (Gulf of Carpentaria) the character of the land gradually improves, while towards the south (South Australia) we have every diversity of soil and surface. “There is no country,” says the Rev. J. E. Woods, “more interesting in its formations, or more varied in its mineral productions, than South Australia; lofty mountains, extensive plains, sandy deserts, and inland seas, are all included in its far-stretching boundaries. With a climate like that of the south of Spain, it possesses the scenery of the Highlands in some places, and in others deserts like those of Arabia, and vying with them for bleakness, aridity, and burning heat. There are chains of salt lakes which render unprofitable a larger area than England; there are marshes and salt-swamps more dank, unwholesome, and extensive than any in the United States; there are rocky precipices and chasms and waterfalls to rival almost the Alps; there are extinct volcanoes of large dimensions, almost as numerous as those of Auvergne; and, finally, there are caves which exceed in magnitude the Guachero caves of Humboldt, or in stalactites the Antiparos of the Ægean Sea.”

Plains of the New World.

94. Turning next to the New World, we find the plains on a much more conspicuous and decided scale, stretching more continuously, and rising less above the level of the ocean. In North America, the *Great Central Plain*, lying between the Rocky Mountains on the west and the Alleghanies on the east, extends, it may be said, from the Arctic Ocean to the Gulf of Mexico, a distance of nearly 3000 miles. Throughout this long course it is only once interrupted by the gently swelling prairie grounds (1500 or 1600 feet in height) that turn the courses of the Red and other rivers to the north, and those of the Missouri and Mississippi to the south. Varying, in wide expanses, from 100 to 600 and 800 feet in elevation, it presents considerable diversity of surface—swampy marsh, grassy prairie, forest-land, and barren ground. The most notable feature in the surface of this great central plain, which occupies an area of nearly 3,000,000 square miles, and has been characterised by Humboldt as “an almost continuous region of savannahs and prairies,” is undoubtedly that of the open, slightly undulating, and grassy portions denominated *prairies*. These prairies are of vast extent: some are rolling, others are flat and level in surface; many of them are treeless,

and covered only with luxuriant grass and flowers ; towards the south some tracts verge into shrubby woodland ; while in the extreme north the soil is largely swampy and desert. The only other notable lowland in North America is the *Atlantic plain*, lying between the Alleghanies and the Atlantic—a district of little elevation, and often flat and swampy, especially towards the south (*e. g.*, Dismal Swamp), in Georgia and Florida. This Dismal Swamp, which may be taken as a type of swamps and morasses in whatever region they occur (always making allowance for the climate and vegetable productions), is thus alluded to by Sir Charles Lyell in his ‘*Travels in North America* :’ “ It bears the appropriate and very expressive name of the ‘Great Dismal,’ and is no less than forty miles in length from north to south, and twenty-five miles in its greatest width from east to west, the northern half being situated in Virginia, the southern in North Carolina. I observed that the water was obviously in motion in several places, and the morass has somewhat the appearance of a broad inundated river-plain, covered with all kinds of aquatic trees and shrubs—the soil being as black as a peat-bog. . . . It is one enormous quagmire, soft and muddy, except where the surface is rendered partially firm by a covering of vegetables and their matted roots ; yet, strange to say, instead of being lower than the level of the surrounding country, it is actually higher than nearly all the firm and dry land which encompasses it ; and to make the anomaly complete, in spite of its semi-fluid character, it is higher in the interior (to the extent of ten or twelve feet) than towards the margin. . . . The soil of the Swamp is formed of vegetable matter, usually without any admixture of earthy particles, and numerous trunks of large and tall trees lie buried in the black mire.”

95. In South America we are presented with three well-marked and distinctive river-plains—viz., those of the Orinoco, the Amazon, and the La Plata. The first is one of the lowest and most level tracts in the world, rising not more than 200 feet at the distance of 500 miles from the sea, and throughout that course marked by swamps, periodically overflowed grass-flats (*llanos*), and tropical forest-growths. The *llanos* occupy an area of about 160,000 square miles, which is almost wholly inundated during the rainy season, but shortly afterwards is so densely covered with luxuriant grasses that it is known to the natives as the “sea of grass.” During the ensuing tropical droughts, these *llanos* become parched and withered ; hence the frequent conflagrations to which they are subject, and hence also, in a great measure, the perpetuation of their treeless character. The second or Amazonian plain,

still more extensive and unique, is characterised by similar grassy plains and forest-growths (*selvas*), and is the largest river-basin in the world, occupying an area of about 1,500,000 square miles. Richly alluvial in soil, periodically inundated, and under the influences of a tropical sun, these selvas present the rankest luxuriance of primeval forest-growth, and are in many places so densely tangled with undergrowth that they are only accessible by the river-courses that traverse their areas. The third, comprising the contiguous basins of the Uruguay, Parana, La Plata, and Colorado, embraces an area of not less than 880,000 square miles, and is characterised chiefly by its deep alluvial soil, broad thistly flats, and grassy pastures, known as *pampas*. Stretching from the flanks of the Andes to the shores of Buenos Ayres, and thence southwards to the deserts of Patagonia, these pampas differ considerably in character, being flat and thistly towards the coast, slightly undulating and grassy towards the interior, and full of bogs and swamps and scrubby ridges as we approach the Andes. The whole region is treeless, verdant during the rains, but withered and parched during the dry season. The desert terrace-land or steppes of Patagonia, extending southward from the Rio Colorado to the extremity of the continent, is a sterile undulating region—the soil shingly and strewn with boulders, the grass stunted, and the climate cold and tempestuous.

Valleys and Minor Depressions.

96. Besides the great plains of the world, there are numerous valleys and minor low-lying tracts that exercise a decided influence on the soil, climate, vegetables, and animals of the countries in which they occur. These are the *dales* and *vales* of existing streams and rivers, the *basins* of lakes and rivers, and the *straths*, *carses*, and *deltas* of our estuaries. Whether they have been formed by subsidences of the earth's crust, by the silting-up and drainage of lakes and morasses, or by the slow erosive power of rivers (*valleys of erosion*), their characters are much alike, and the purposes they subserve identical. Their low-lying situations, their tempered climates, their rich soils, and well-watered surfaces, have ever rendered them the grand nurseries of vegetable and animal growth; and this fertility and amenity has ever attracted the human race, and rendered them the main theatres of industry and civilisation. To particularise the lesser valleys—the dales and vales that confer amenity and richness on the land-surface—would be merely to enumerate the rivers and streams that flow

through the different continents. Every stream has in some part or other of its course its strip or patch of valley-ground; and these occur of every extent, from the meadow of a few acres to the dale of many leagues; at all altitudes, from the *polder* and *fen*, protected from the tides by embankments, to the valley high among the mountains; and in every variety of surface—morass, silt, sand, gravel—from the *warp* of the latest flood to the green-sward of a thousand centuries. In civilised countries these lowlands are the principal seats of culture and husbandry, while in semi-civilised regions they constitute the pasture-lands of the nomadic shepherd and herdsman.

97. Besides the dales and vales and valleys properly so called, there are also the deltas of many rivers—low-lying tracts still in course of formation, and which, from their swampy and partially-inundated character, can scarcely be said to belong to the domain of the land. To this category belongs much of the deltas of the Nile and Niger, the Indus and Ganges, the Mississippi, and the Orinoco and Amazon. The older and higher portions of these deltas have long since been converted into fertile alluvial plains, but the lower portions consist largely of mud-flats, sandbanks, and lagoons, partially covered with jungle-growth during the dry season, yet inundated as far as the eye can reach during the periodical overflows of their rivers. In fact, it is the low, level, and sedimentary nature of these deltas that compels the rivers to seek their way to the sea by many *mouths* or outlets—these outlets being alternately silted up, shifted, bifurcated, and converted into lagoons and reaches, according as the flood or sediments prevail. In course of time, however, the existing mud-flats and sandbanks, increasing and consolidating, will be converted into alluvial land, and other banks and shoals will arise as new sediments are carried forward into the area of the ocean. We have here alluded merely to the larger and more notable of deltas, but the student must remember that every river that carries down sediment is forming to some extent a deltic accumulation at or near its embouchure—and this whether in lakes, like the Rhone in Lake Geneva—in inland seas, like the Po in the Gulf of Venice—or in the ocean itself, as the Niger and Amazon. Besides these river-deltas properly so called, there are also considerable low-lying tracts of marine silt and sand-drift, formed, and still forming, along many of the more sheltered bays and recesses of the ocean. These, like the *links* of our own islands, the *landes* of France, the *dunes* of Holland and Denmark, the *fens* and *levels* of England, the *carses* of Scotland, and the *swamps* of Florida, are gradually on the increase and in process of time assume a flat or plain-like surface.

98. As there are plains and valleys at considerable elevations, and others again scarcely raised above the overflow of the tides, so there are several areas of the land surface depressed even beneath the general level of the ocean. Laying aside some tracts of the Sahara which are said to sink beneath the sea-level, the most remarkable of these ascertained depressions are the Aralo-Caspian basin, and the trough of the Dead Sea. The former of these, in which are situated the Caspian and Aral seas, is a depressed area of 162,000 square miles in extent, and all considerably below the ocean—the surface of the Caspian, the lowest portion of the cavity, being actually 83 feet beneath the level of the Black Sea. The Dead Sea, though a mere trough in comparison with the Caspian, is still more remarkable for its depression—the surface of the water being from 1290 to 1298 feet (according to the season of the year) lower than that of the Mediterranean, from which it is 50 miles distant, and separated by high ground prolonged to the southward from the mountain-range of the Lebanon. Whatever the origin of these cavities—whether by subsidence of their areas or by upheaval of barriers that cut them off from the general ocean—it is clear that were their river-supplies not fully counterbalanced by evaporation they would in process of time become filled with water, and their surplus find an outlet by the lowest course to the sea. The Aral and Caspian would be discharged into the Euxine over the low steppes of the Volga and Don ; while the waters of the Dead Sea would find their way to the Gulf of Akaba in the Red Sea, with which, at some former period, it was evidently connected by the dry stony valleys or “wadies” that now lie between.

Origin and Characteristics of Lowlands.

99. As the terrestrial *highlands*—the mountains and table-lands of the world—owe their origin chiefly to the elevatory forces of vulcanicity, so the *lowlands*—the plains, deserts, and valleys—depend for their formation mainly on the levelling effects of water. Many of the larger plains are but old sea-beds—shoals and banks and marine plateaux—that have been gradually elevated above the waters ; others are the accumulated silts of shallow seas and bays ; while some, again, have been formed by the slow alluvial increment of river-deltas. Of the minor plains and valleys, many occupy the sites of former estuaries, partly silted up and partly upraised ; others, the areas of lakes and morasses now converted into dry land by the double process of silting and

drainage ; while others, again, have been formed by the erosive and levelling operations of rains, streams, and rivers. Wherever we have a flat and uniform surface of any extent, there, we may rest assured, the smoothing and levelling powers of water have been exerted, and this whatever the nature of the soil and subsoil, —whether rich alluvial silt, vegetable earth, clay, sand, gravel, or loose stony shingle. The superficial aspects of these lowlands have, of course, been considerably changed since their first formation, and are still undergoing modification under the influence of meteoric and aqueous agency. Wet and swampy marshes have been and are still being converted into dry land by the accumulation of vegetable soil ; slimy mud-flats clothed with verdure and forest-growth ; flat and uniform surfaces grooved and furrowed by water-channels ; and sandy plains blown into shifting dunes and ridges. The general features may long remain with little perceptible alteration ; the minor surface-changes are incessant and interminable.

100. The main characteristics of plains and valleys, as compared with those of mountains and table-lands, are : 1. Their low-lying situations, which, latitude for latitude, confer on them a milder climate, and thus permit the growth of plants that refuse to flourish at higher elevations ; 2. Their soil and subsoil, which, for the most part, consist of loose detrital and alluvial matter, favourable also to vegetable growth as compared with the hard rocky structure of hills and mountains ; 3. The general tendency of their soils to be further increased and renewed by fresh detritus borne by streams and rivers from the adjacent highlands ; 4. The favourable nature of their surface for the formation and increment of rivers by which they are usually traversed ; 5. Their uninterrupted facilities for the dispersion of plants and animals ; 6. Their accessibility by river-navigation ; 7. Their amenity for culture, unless where rendered sterile by cold or desert by drought ; and 8. Their general fitness for the purposes of human settlement and civilisation—being readily traversed by roads, railways, and canals. These and similar characteristics, which will readily suggest themselves to the reflecting student, sufficiently distinguish the lowlands from the highlands of the terrestrial surface, and render still more apparent the intimate union that everywhere subsists between the vital and physical in the scheme of the universe.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the two preceding chapters we have endeavoured to present an outline of the superficial features of the land, as composed of mountains and table-lands, of plains and valleys, and the relation they bear to each other in the scheme of Physical Geography. Whatever be the geological law that regulates the successive upheaval and submergence of large tracts of the earth's crust, we see in the arrangement of the present continents the more violent effects of the igneous action and contraction in producing abrupt and mountainous irregularities, and the more gradual efforts of air and water in moulding into uniformity of surface its plains and valleys. Whatever be the nature of the vulcanism acting from within, we see that it exerts itself along certain lines and in definite centres, and these lines and centres give rise to mountain chains and groups, and these again give contour and configuration to the terrestrial areas. In the Old World, as already stated, the main axis of elevation is from east to west; hence the greatest length of the continent in this direction, and hence also the determination of the rivers and river-plains in northerly and southerly courses from this axis. In the New World, again, the main line of elevation is from south to north; hence, also, the corresponding direction of that continent and the opposite courses of the principal rivers. As with the main continental masses so with the minor spurs and peninsulas—their direction of greatest length being invariably regulated by the direction of their hills. Geology thus becomes the obvious groundwork of geography; and on reference to the Geological Map of Europe, for instance, it will be seen that all the granitic, trappean, and volcanic outbursts are but expressions, in other terms, for the extent and directions of the mountains of that continent. As the great plains are but the undisturbed portions of the continents, they will naturally take the same main direction as the mountain-ranges; just as the table-lands which are upraised by the mountains will be situated among their groups or along their axes. On the other hand, the rivers, obeying the laws of descent from the opposite sides of these axes, will have their valleys and dales running less or more in cross-courses, thus giving additional features of diversity to the land.

Mountains and table-lands, plains and valleys, are thus but the counterparts of each other; and rugged and inhospitable as the former may seem, the latter would be but thirsty deserts were it not for the clouds and rains, the streams and rivers, that are

generated among their summits, and descend in perennial supplies from their glens and recesses. Botanically and zoologically, mountain and plain has each its own peculiarities and numerical abundance of forms—these forms becoming fewer and of less importance as we ascend, and more abundant and of higher biological value as we descend into the sheltered and fertile lowland. Ethnologically, as mountain regions have ever been the nursing-fields of hardy, brave, and independent races; so plains and valleys have ever been the chosen seats of settled industry and civilisation. The plains of China and Hindostan, of the Tigris, the Euphrates, and the Nile, were the early and populous abodes of mankind in the Eastern hemisphere, just as in the Western the valleys of the Missouri and the Mississippi were the chosen grounds of primitive mound-building races. And as in former ages; so even now the principal sites and centres of industry are to be found in the river-plains of the Old and New Worlds—the causes that induced the early shepherd settlers being equally operative on their agricultural, city-dwelling, mechanical, and commercial descendants.

VIII.

THE WATER—ITS OCEANS AND SEAS.

Their Area and Configuration.

101. HAVING considered the various conditions of the Land—its area, configuration, highlands, and lowlands—we now turn to those of the Water, as exhibited in its oceans and seas, their areas, depths, composition, tides, currents, and kindred phenomena. And here it may be observed of WATER, which forms so important an element in the constitution of the globe, that, chemically speaking, it is the *protoxide of hydrogen*, consisting of two volumes of hydrogen and one of oxygen, or of eight parts of oxygen to one of hydrogen by weight—88.89 oxygen and 11.11 hydrogen. When pure and at ordinary temperature, it is fluid and amorphous, without taste or smell, colourless in small quantities, but in large masses of a peculiar bluish-green or blue. The specific gravity of pure or distilled water, at 62° Fahr., is assumed at 1.000, and is taken as the standard of gravity for all other bodies; but sea-water varies, according to locality and the depth from which it is taken, from 1.024 to 1.029. When heated to the temperature of 212° Fahr. at the level of the sea, and under the ordinary pressure of the atmosphere, water boils, and is converted into steam, a cubic inch of water being converted into 1696 cubic inches of steam. The absolute temperature at which water boils (its boiling-point) becomes less and less as we ascend above the sea-level. In other words, as the weight of the atmospheric column becomes less, *ebullition*, or the phenomenon of boiling, takes place at a lower temperature; and this decrease in the temperature of the boiling-point of water as we ascend into the higher regions of the atmosphere, like the corresponding decrease in the height of the mercurial column of the barometer—affords the observer a ready means of calculating his approximate elevation above the

level of the sea. The effects of boiling at the sea-level, and boiling at an elevation of 12,000 feet, are, however, two very different things—the temperature falling eight-tenths of a degree for every half-inch of the barometer; and what would be cooked by the former heat, might remain unchanged for hours under the influence of the latter. Of all known substances, water has the greatest *specific heat*; that is to say, it requires more heat to raise it through a given range of temperature than any other known substance. If a pound of mercury and a pound of water are both raised one degree, it requires the application of 33 times as much heat to do this for the water as for the mercury: again, if both are allowed to cool one degree, it will be found that the water sets free 33 times as much heat as the mercury. At $39\frac{1}{2}^{\circ}$ Fahr. fresh water is at its minimum volume and maximum density, expanding and becoming lighter as it rises above that temperature, till it is wholly converted into vapour, and also, as it falls below it, till at 32° it is converted into *ice*—a transparent, brittle, crystalline solid, which weighs 55.5 lb. a cubic foot, has a specific gravity of .918, and a volume increased in the proportion of 1.099 to 1. The point of maximum density of salt water is considerably lower than that of fresh, even below 32° ; while its freezing-point is at least as low as $28\frac{1}{4}^{\circ}$.

102. Water, as found on the earth, is never absolutely pure, but contains more or less of various substances, as atmospheric air, carbonic acid, nitrogen gas; silica, alumina, and salts (carbonates, sulphates, nitrates, phosphates) of lime, magnesia, soda, potash, protoxide of iron, manganese; or chlorides and fluorides of their metallic bases; and in the sea and some saline springs, also iodine and bromine. Like all other fluids whose particles are free to arrange themselves, water at rest always assumes a level surface, and this surface, in the case of the ocean, corresponds with, and forms part of, the circumference of the globe. The only exception to this uniformity of level is in the case of capillary tubes (tubes with hair-like bores) and narrow interstices, in which it rises slightly above its general level; and this *capillarity* is of essential service in disseminating moisture through the pores of soil and rocks, and it may be through the tissues of the vegetable kingdom. As an agent in nature, water is indispensable to the life of plants and animals; it enters into the composition of all bodies, whether organic or inorganic, and in the form of rain, streams, rivers, waves, tides, and currents, is the great modifier and remodeller of the geological aspects of the globe. Water, in fine, is everywhere—in the atmosphere, in visible or invisible form; in the tissues of plants and animals; and in the substance of the rocks and min-

erals that compose the solid crust. It is the great solvent and circulatory medium in nature, without which life would be impossible, and the inorganic world would be deprived of its main modeller and modifier.

Many of the physical properties of water—as bearing on the problems of physical geography—are at once curious and important, viz.: its capillarity; its all but incompressibility, yielding only a 51-millionth under the pressure of the atmosphere, or the 32,000th part of its bulk, under a ton per square inch; its maximum density or minimum volume at $39\frac{1}{2}^{\circ}$; its expansion as ice to one-ninth of its bulk, at 32° for fresh water, and at $28\frac{1}{4}^{\circ}$ or less for salt water; its expansion as steam to 1696 times its bulk at 212° ; and, again, its contraction as ice at temperatures below zero, by which its mass is broken up and dispersed in the polar seas.

103. It has already been noticed (par. 41), that though encircling the globe on every side, and spreading over nearly three-fourths of its surface, the great “world of waters” is more or less configured into certain expanses which are termed *oceans*; and thus we have on the west of the Old World, and between it and the New, the *Atlantic Ocean*—while on the west of the New World, and between it and the Old, spreads out the still vaster area of the *Pacific*. These divisions become apparent on the most cursory inspection of the map of the world—the former lying like an irregular valley between the two continental land-masses, and communicating freely with the arctic and antarctic waters; the latter narrowed to a mere strait on the north, but spreading out towards the south over nearly half the globe, and ultimately losing its individuality in the undefined expanse of antarctic waters. Besides the Atlantic and Pacific, the *Arctic* and *Antarctic* constitute well-recognised though imperfectly known oceans; while between Africa and Australasia stretches the familiar and much-traversed area of the *Indian Ocean*. In treating of these great oceanic expanses, various names and subdivisions are employed by navigators, but for all practical purposes in Physical Geography the terms North and South Atlantic, North and South Pacific, Arctic, Antarctic, and Indian Oceans, are sufficiently explicit and comprehensive. Or, looking upon the waters that extend southwards from the extreme points of Africa, Australia, and South America as one great united mass, the term *Southern Ocean* will often be found to be convenient, and not inappropriate.

104. Taking the Atlantic Ocean as extending from the arctic to the antarctic circle, its length is upwards of 9000 miles; its breadth varies from 900 to 4000 miles, being only 900 between

Norway and Greenland, 1700 between Sierra Leone and Brazil, and 4100 between Marocco and Florida ; and its computed area is about 25,000,000 square miles. This vast expanse is little interrupted by islands. In its northern section it is irregular in form, and throws several important branches into the land ; but in the southern its form is regular, and its shores comparatively uniform. Towards the north it is partly enclosed by the rocky coasts of Greenland, Iceland, and Norway ; but towards the south it is quite open, and merges broadly into the Antarctic Ocean. The leading branches are Baffin and Hudson Bays, the Gulf of St Lawrence, Bay of Fundy, Gulf of Mexico, and the Caribbean Sea, on the west or American side ; and on the east or Old World side, the North Sea, Baltic Sea, English Channel, Bay of Biscay, the Mediterranean Sea, and the Gulf of Guinea. All, or nearly all, of these recesses occur in the northern division of the Atlantic ; hence the greater interest of this section to the geographer, naturalist, and navigator.

105. Of the minor seas or ramifications belonging to the Atlantic (some of which are ice-locked for a considerable portion of the year, and others encumbered by reefs and shoals), the most important, physically and vitally, is the Mediterranean, whose shores formed the early nurseries of civilisation and commerce, and whose waters are still the highway of communication, not merely between the three continents—Europe, Asia, and Africa—which encircle its shores, but between these and every other portion of the globe. “The political and social events which have occurred on the shores of this remarkable part of the ocean,” says Admiral Smyth in his instructive Survey, “are closely connected with the history of almost every country in the world ; but, independently of its classical and historical associations, the Mediterranean still confers invaluable advantages upon the numerous occupiers of its coasts, and through them on the interior of the surrounding continents. It is, moreover, the great bond of intercourse between the nations of Europe, Asia, and Africa, although it appears as if it had been destined to keep them asunder. Beautifully diversified with islands, and bounded by almost every variety of soil, its products are proportionally various ; and from its communication with the Atlantic, it facilitates commerce with every part of the globe. Here navigation made its earliest efforts ; and the comparative shortness of the distances between port and port, by rendering the transit easy even to imperfect vessels, tended to promote and diffuse civilisation ; it being an unquestionable axiom that whatever is calculated to make men better acquainted with each other, whether the inhabitants

of distant lands or neighbours, must invariably produce beneficial results for the whole."

106. The Pacific Ocean, though less important as a highway of commerce, occupies nearly twice the expanse of the Atlantic—its greatest breadth being 12,000 miles, and its computed area about 50,000,000 square miles. Unlike the Atlantic, it is almost entirely shut out from communication with the Arctic Ocean—the only passage of connection being that of Behring Strait, not more than 36 miles in width, with a maximum depth of 25 fathoms; but, like the Atlantic, the Arctic opens out towards the south, and merges undefinedly into the Antarctic. It is thickly studded with islands and clusters of islands, and these physically and vitally constitute one of its most distinctive features. Its leading branches are the Sea of Kamtchatka, Sea of Okhotsk, Sea of Japan, Yellow Sea, and Chinese Sea, on the west or Asiatic side; while on the east or American side, the Gulf of California and the small bay of Panama are the only indentations that break the uniformity of its coasts. The most important of these minor seas are those of Japan and China, whose shores have been the seat of an early and peculiar civilisation, and whose waters have long been traversed—and every newer generation still more frequently traversed—by the ships of every maritime country.

107. The Indian Ocean, stretching between Africa and Australia on the one hand, and between Asia and the Southern Ocean on the other, is upwards of 4000 miles in breadth, and is computed to have an area of about 17,000,000 square miles. If we except the Indian Archipelago, which forms its boundary rather than belongs to it, it is encumbered by few islands; and it also penetrates the land by few branches—the Red Sea, Arabian Sea, Persian Gulf, and the Bay of Bengal, being the only minor seas—and these all on its northern or Asiatic boundary. The most important of these minor branches are the Red Sea and the Bay of Bengal—the former early and intimately connected with the history of man, and the latter, the leading highway of modern commerce to the varied wealth of India.

108. The Arctic and Antarctic Oceans, from their circumpolar situations, are largely blocked up with ice, and consequently but imperfectly known to geography. The Arctic forms, as it were, a circular basin, bounded in general by the northern coasts of Europe, Asia, and America, which remarkably conform to the parallel of 72° , and having an area roughly estimated at 4,000,000 square miles. It penetrates northern Europe by the White Sea and Sea of Kara, and northern Asia by the Gulf of Obi and a few small inlets, and northward from these shores seems interrupted

by comparatively few islands. The northern shores of America, however, present so many islands and ice-locked inlets that it has, up to the present moment, been impossible to determine whether land or water continues northward and surrounds the pole, notwithstanding the repeated heroic attempts that have been made to solve the problem. As far as the Nares Expedition has determined—and it reached $83^{\circ} 20' 26''$ N. lat.—the sea is encumbered all the year round with floebergs of considerable magnitude; hence its not inappropriate title, Palæocrystic Sea (Gr. *palaïos*, ancient; *kryos*, ice), or sea of ancient ice. At that point the depth was 72 fathoms; the bottom temperature of 28.8° Fahr.; the surface temperature of 28.5° Fahr.; and the air temperature of 8° Fahr. in May 1876. The Antarctic Ocean, on the other hand, is open on all sides to the Pacific, Atlantic, and Indian Oceans, which thus insensibly merge themselves into the great Southern Ocean. So far as navigators have ventured to approach the southern pole, various islands and shores have been observed which would favour the idea of a circumpolar continent; but whether land, sea, or an ice-bound archipelago occupies the immediate region of the pole, is likely long to remain an undetermined problem. Altogether, the Antarctic is a cold, boisterous, and unapproachable ocean—its ice extending 10° nearer the equator than that of the Arctic—offering few of those inducements that have stimulated repeated research in the Northern Ocean.

109. Such are the areas occupied by the waters of the ocean—areas and subdivisions which are not only necessary to intelligible description, but which are marked in reality by different characteristics in nature. Generally speaking, position on the globe decides their surface temperatures; area and configuration determine their tides and currents; and the sum of these physical conditions regulates the nature and distribution of their plants and animals. Any change, therefore, either in position, area, or configuration, would be attended by a corresponding change of conditions, and any such alteration would affect all the consequences, physical and vital, that depend on external conditions. As they exist, the North and South Atlantic, situated under different latitudes, enjoy different temperatures; while the North, by virtue of its greater irregularity of form, and numerous ramifications into the land, exhibits a much more varied display of vegetable and animal life. The same also holds good of the North and South Pacific, with these important modifications, that the North Pacific, compared with the North Atlantic, is almost excluded from Arctic influences, while the numerous islands of the South Pacific

occasion conditions, physical and vital, peculiarly its own. The Indian Ocean, surrounded on three sides by land, and situated, for the most part, in the torrid zone, presents peculiarities unknown in other subdivisions; while the Arctic and Antarctic, receiving the minimum of solar heat, are ice-locked for the greater part of the year, and have little in common with the other sections of the ocean. As already stated, it is on these primary relations of position and configuration that the different temperatures, tides, and currents of the various oceanic subdivisions depend; and it is entirely owing to these conditions that the specific life of one sea or ocean differs from the life of all other seas and oceans. And yet it must be borne in mind that, though diversely situated and characterised, there is still the most intimate connection and interchange between their waters—the colder usually flowing under and towards the warmer, and the warmer over and towards the colder, so that in this respect they constitute in reality one great and indivisible “world of waters.”

Composition, Density, Pressure, Depth, &c.

110. This great ocean, in all its areas and ramifications, is characterised by a greater or less degree of *saltiness*—this saltiness arising from the presence of certain substances held in chemical solution in its waters. These substances are chloride of sodium (common salt), and sulphates of magnesia and lime, together with minor and varying proportions of salts of potash and ammonia, iodides and bromides of sodium, carbonate of lime, silica, &c.—amounting in all from $3\frac{1}{2}$ to 4 grains to the hundred of water. According to M. Regnault, the following is the mean of several analyses of sea-water:—

WATER, . . .		96.470
SALINE INGREDIENTS, 3.505.	Chloride of sodium, .	2.700
	Chloride of magnesium, .	.360
	Chloride of potassium, .	.070
	Sulphate of lime, .	.140
	Sulphate of magnesia, .	.230
	Carbonate of lime, .	.003
	Bromide of magnesium, .	.002
Loss (including iodides, silica, &c.), . . .		.025
		100.100

The preceding ingredients may vary in different seas, and according to the locality whence, and the season when, the water is taken, but only to the extent of a fractional percentage—the

incessant circulation and intermingling of the ocean's waters by waves, tides, and currents, producing a uniformity, or all but uniformity, in its saline composition. It has been found, however, that the waters of the Southern Ocean are slightly salter than those of the Northern ; that the greatest saltness takes place along the parallels of 22° north and 17° south, or in the courses of the trade-winds, which absorb and carry off an excess of evaporation towards the equator, where it descends in freshening rainfalls ; and that from these limits of maximum saltness there is a slight progressive diminution towards either pole.

In the southern hemisphere, says Captain Maury, there is more sea and less land than in the northern. But the hydrometer indicates that the water in the seas of the former is salter and heavier than the water of seas cis-equatorial ; and man's reasoning faculties suggest, in explanation of this, that this difference of saltness, or specific gravity, is owing to the excess of evaporation in the southern half, excess of precipitation in the northern half, of our planet. "When water passes at 212° Fahr. into steam, it absorbs 1000° of heat, which becomes insensible to the thermometer, or latent ; and, conversely, when steam is condensed into water, it gives out 1000° of latent heat, which thus becomes free, and affects both the thermometer and the senses. Hence steam of 212° Fahr. will, in condensing, heat five and a half times its own weight of water from the freezing to the boiling point."—*M'Culloch*. Now there is in the southern a very much larger water-surface exposed to the sun than there is in the northern hemisphere, and this excess of heat is employed in lifting up vapour from (and rendering salter) that broad surface, in transporting it across the torrid zone, and conveying it to extra-tropical northern latitudes, where the vapour is condensed to replenish our fountains, and where this southern heat is set free to mitigate the severity of northern climates.

111. Though communicating freely (by currents and counter-currents) with the ocean, the majority of inland seas are less salt than the ocean, in consequence of the influx of rivers into their circumscribed areas ; but some, like the Red Sea, receiving no rivers, and subjected to active evaporation, have their saltness slightly in excess. As a general rule, inland seas receiving numerous rivers, and from their situation subjected to little evaporation, will be fresher than the ocean (*e. g.*, the Baltic and Black Seas) ; while others also receiving rivers, but subjected to a more active evaporation (as the Mediterranean), will have their saltness somewhat in excess. Though the saltness of the sea be pretty uniform at great depths, still at the surface, owing to the

admixture of rain, river, and iceberg water, it is not quite so salt; and this freshness will increase, of course, according to proximity to the mouths of the entering rivers. It has also been ascertained that water from the surface contains less air than that from depths, and the difference may equal one-hundredth of the volume of water; while that from greater depths is richer in carbonic acid.

Referring to the Porcupine expedition of 1869, Dr Carpenter says, "that whilst the percentage of oxygen in *surface*-water averaged about 25 per cent, and that of carbonic acid averaged somewhat less than 21, the oxygen in *bottom*-water did not average above 19.5 per cent, while the carbonic acid increased to nearly 28—the percentage of nitrogen being reduced at the same time from 54 to 52.5. The percentage of carbonic acid often rose much higher than this, being frequently between 30 and 40, and in one instance more than 48; but the percentage of oxygen did not show a corresponding reduction, being never less than 16, while that of nitrogen came down from 54 to 34.5. Thus it appeared that *so long as oxygen was present in sufficient proportion*, the increase of carbonic acid to nearly half the amount of the gases removable by boiling did not exert any unfavourable influence on animal life; from which it might be surmised that the carbonic acid *dissolved* in water under great pressure is in a condition altogether different from that of *gaseous* carbonic acid as regards its relation to animal respiration.

112. Another noticeable property of salt water is, that it is less sensitive, if we may so speak, to cold than fresh water—the latter freezing, as is well known, at 32°, while sea-water is not converted into ice till the thermometer sinks to 28½° Fahr. It is likewise less vaporisable than fresh water—that is, a given extent of salt-water surface gives off less vapour during the same time, and under the same conditions, than an equal extent of fresh-water surface. Such composition and properties are no doubt all-essential in the economy of nature. Shell-fish, crustacea, coral-zoophytes, and other creatures, derive the calcareous matter of their structures from the salts of the ocean; fishes breathe the aerated waters of the sheltered and undisturbed depths; and both plants and animals obtain conditions of existence which absolutely pure water would fail to supply. By its lower freezing-point a larger amount of surface is ever kept open and accessible; and by its slower evaporation a less amount of moisture is borne from its greater expanse to the comparatively smaller surface of the land. As sea-water freezes (the ice being fresh) the surface portions become salter and salter, and then,

through their greater specific gravity, sink downward, while the lighter and warmer portions arise to supply their place—a circulation which at once limits the surface-cold and maintains the equilibrium of density.

113. It will be seen that no notice has been taken in the preceding paragraphs of ingredients—sand, mud, and organic debris—that may be *mechanically suspended* in the waters of the ocean. These are purely local and accidental, depending on river-floods, tidal currents, waves, storms, and other commotions. When the commotion subsides, the waters regain their transparency; and altogether, unless along wasting shores, in tidal estuaries and river embouchures, there is really very little matter mechanically suspended in the waters of the ocean, and that in particles of infinitesimal minuteness. On the other hand, the ingredients held in *chemical solution* are all but constant and universal. The water that evaporates from the ocean is all but absolutely pure: it falls on the land in mist and rain and snow; percolates the soil and rocks; and returns again to the ocean, carrying with it the saline substances it has dissolved from the rocky strata. The ocean is thus the great equalised repository of all that is borne from the continents; and there they would accumulate, were it not for the beautiful counterpoise that is ever kept up by the requirements of plants and animals, as well as by the intervention of new chemical arrangements among its multifarious sediments. So far as Geology can determine by a study of the marine life (shell-fish, corals, foraminifera, &c.) of former ages, the composition of the ocean seems to have been much the same as it is now; and thus, in all our reasonings, we may regard its saline contents as having long arrived at a state of equilibrium and fixity. Even if there were a slight excess at any one period, that excess would be merely temporary, as those incessant mutations of sea and land, involving the formation of new limestones, magnesian limestones, rock-salts, and the like, are ever taking up the surplus, and restoring the equilibrium.

114. *The mean specific gravity of sea-water*, as compared with absolutely pure water at 62° Fahr., is found to be 1.0275—an amount that corresponds to a percentage of 3.505 of saline ingredients. The salter, therefore, that water is, the greater its gravity; and hence the fresh water of rivers, of melting icebergs, &c., will float for many miles on the surface of the sea before the two fluids are thoroughly diffused and commingled. It is owing to this that potable water has been *skimmed* from the surface several miles from the mouths of large and rapid rivers; and it is also for this reason of unequal densities that currents are established

in different parts of the ocean—the heavier ever seeking to establish its equilibrium. On the whole, the difference in specific gravity between the two great oceans is very slight: thus, in the N. Pacific, it is 1.0254; in the Indian Ocean, 1.0263; and in the northern part of the Red Sea, 1.0279. As already mentioned, fresh water acquires its minimum volume, or greatest density, at a temperature of $39\frac{1}{2}^{\circ}$, and becomes lighter and lighter as it rises above this temperature to its point of evaporation, or sinks below it down to its freezing-point.

115. Again, water being slightly compressible, it follows that at great depths in the ocean the water will be denser than at the surface, and consequently what takes place near the shore will be impossible at extreme depths. According to experiment, water at the depth of 1000 feet is compressed $\frac{1}{340}$ th of its bulk; and at this ratio the pressure at the depth of one mile would be equivalent to 160 atmospheres, or 2320 lb. on the square inch; while at the depth of 4000 fathoms, or about $4\frac{1}{2}$ miles, it would amount to 750 atmospheres! It is owing to this enormous pressure that corked bottles sunk to great depths have their corks always forced in; and that pieces of oakwood carried down to similar depths have their fibres and pores so compressed as to be afterwards incapable of floating on the surface. This pressure, being equal on all sides, does not affect the life of the deepest ocean any more than the pressure of the atmosphere (15 lb. to the square inch) affects the life of the terrestrial surface. We shall afterwards see, when treating of the distribution of marine life, how, and to what extent, it is influenced by pressure, heat, light, composition of water, nature of sea-bed, and other physical conditions; and meanwhile need not further allude to the vital aspects of the subject.

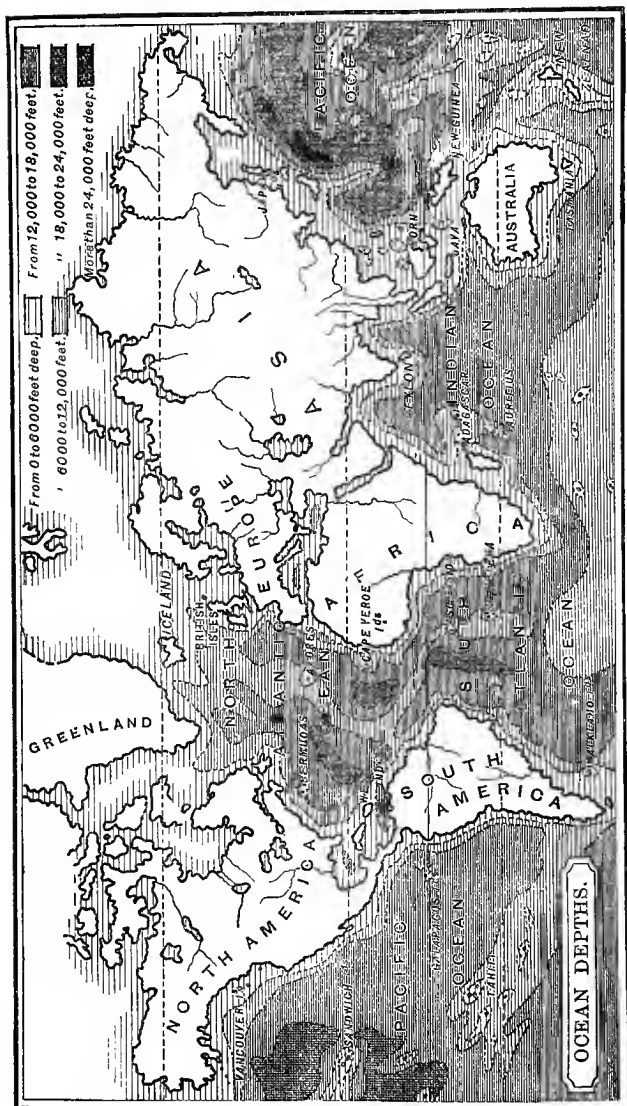
116. Touching the *depth of the ocean*, it has been already observed, that as the dry land rises variously and irregularly above the level of the ocean, so the bottom of the ocean sinks variously and irregularly beneath its waters. The soundings of navigators establish the fact that there are shallow shoals and banks, deeper flats and plateaux, and still deeper troughs and valleys; and that were the whole dry, we should have presented to us inequalities of the same kind as are presented by the surface of the land, but upon a somewhat larger scale. In all probability the bed of our present ocean is but the submerged surface of former lands; but—unless, perhaps, in the instances of coral-reefs and submarine volcanoes, the outer edges of which usually descend suddenly into deep water—it may be regarded as certain that the contour of the ocean-floor is much smoother and more flowing than that of the

dry land. The sharp irregularities of the land-surface—its abrupt heights, its overhanging cliffs, its narrow gorges and deep valleys—have their origin in the local and ever-varying effects wrought by rain and rivers upon the ever-varying rocky materials by which that land-surface is underlain. But as the floor of the present ocean areas slowly sank during the progress of submergence, its minor irregularities must have been more or less planed away by the erosive action of the waves within tide-marks. As it sank still lower beyond the reach of the waves, thick sheets of the usual coarse shore-sediments must have been flung down upon it, filling up its minor hollows and masking all its smaller prominences. Finally, as it descended, in the course of long geological periods, to its greatest depth, the continuous but gradually diminishing rain of sediment upon it must, of necessity, have given its upper surface that soft plain-like contour which has been held by some to be characteristic of the deepest parts of the ocean-floor.

117. As a general rule, it may be stated that, where the land slopes gradually towards the ocean, the waters also deepen gradually; and, on the other hand, where the land descends abruptly, the sea deepens, in like manner, suddenly and abruptly. In fact, this is only the natural consequence of slope and counter-slope,—a great relation, to which there is scarcely an exception. The northern plains of Russia and Siberia, for example, slope gradually into the shallow bed of the Arctic Sea, just as the abrupt terminations of South America, Africa, and Australia dip suddenly into the deeper waters of the Southern Ocean. The level plains of China spread gently outwards into the shallow waters of the Yellow Sea; the low shores of eastern England, in like manner, slope slowly into the comparatively shallow basin of the North Sea; while, on the other hand, the precipitous coasts of Norway dip suddenly down into a corresponding depth of water. This fact, that low lands are generally bordered by shallow seas and high lands by deeper water, affords no idea, however, of the depths of distant and central expanses, and for these we must either appeal to theoretical deduction or to actual observation.

118. So far as experiment is concerned, comparatively little is known of the absolute depth of the ocean; and even where deep soundings have been made, there has been great liability to error, partly from the imperfection of the apparatus employed, and partly from the chance of the line being deflected from the perpendicular by the force of under-currents. Our knowledge, however, is being rapidly extended, and in a few years we shall know much not only of the mere depth, but of

the nature of the sea-bed, and of the kind of life (vegetable and animal) by which the extreme depths are peopled. It appears probable that the extreme depths of the sea correspond to the extreme heights of the land—that is, as the highest mountains rise little above five miles, so the greatest depths sink little below that amount; but this is a mere coincidence, there being no necessary connection between the two phenomena. The *mean elevation* of all the land—continents and islands, mountains and plains—was formerly estimated by Humboldt at somewhat less than 1000 feet; and the *mean depth* of the ocean was calculated by Laplace, from tidal waves and kindred phenomena, to be at least 21,000 feet, or about four English miles. It was supposed, however, that a very large proportion of the ocean is comparatively shallow, and not a tithe of this depth; and therefore, to make up the mean, some other portions must be proportionally deeper, to the extent, perhaps, of eight or ten miles. Indeed, soundings (open to the objections given above) were made in the South Atlantic, both by British and American navigators, varying from 27,000 to 46,000 feet; while from calculations on the velocity of tidal waves, which are found to proceed according to the depth of the channel, it was estimated that the extreme depths of the same ocean are about 50,000 feet, or more than nine miles. But the careful investigations carried on of late years render it very doubtful if any part of the ocean-floor reaches this enormous depth. Our acquaintance with all the more important ocean phenomena has been greatly augmented of late by the extended and carefully conducted researches made by the officers of the Challenger expedition, which, under the command of Professor Sir Wyville Thomson, circumnavigated the globe during the years 1872-76. The general contour of the ocean-floor, as deduced from their observations and the confirmatory and supplementary results obtained by American and Norwegian investigators, is shown in the map of the ocean depths given upon page 134. Of the inner and ice-bound areas of the polar seas we have still no precise knowledge, but of the general form of the three chief oceans of the globe we are now beginning to gain a fair conception. While the average height of the land above the sea-level is only about 900 or 1000 feet, the average depth of these ocean-basins cannot be less than 15,000 or 16,000 feet. The *Atlantic Ocean* has an average depth of 12,000 feet; but this depth is by no means uniform throughout. There is a rapid descent on both sides from the edges of the continents into deep water—a depth of 6000 feet being reached generally within 100 miles of the shore, and a depth of 12,000 feet in about the same distance be-



yond. After attaining this depth, the ocean-floor spreads itself out in two vast and gently sloping valleys, several hundreds of miles in width, and ranging down both sides of the Atlantic parallel to the outer margins of its bounding continents. These valleys are divided from each other by a broad ridge which runs down the centre of the ocean-basin from Iceland to the Antarctic continent. The upper surface of this central ridge reaches to within 10,000 feet of the surface, and upon it are situated the volcanic islands of the Azores, Ascension, St Helena, &c. The two grand ocean-valleys separated by this ridge descend generally to a depth of 18,000 feet, but include within them three interior depressions or "abysses" of much greater depth. The first of these hollows lies between the Bermudas and the West Indies, and has a measured depth of 23,250 feet, or more than four miles. The second occurs west of the Canaries, with a depth of 18,900 feet. The third lies midway between Brazil and the island of St Helena, and has a depth of 20,700 feet. The *Indian Ocean* has an average depth of 16,000 feet. It shows the same rapid descent along its continental margins into deep water as the Atlantic. Its interior appears to be a broad and flat depression about 18,000 feet in depth. The floor of the *Pacific Ocean*, which averages 21,000 feet in depth, is on the other hand greatly diversified. Its eastern portion is formed of an enormous ocean-valley some 18,000 feet in depth, which ranges parallel with the steeply descending edge of the American continent from Alaska to Juan Fernandez. Its central parts are apparently occupied by vast submerged platforms, which rise within 12,000 feet of the surface, and upon which are scattered the host of oceanic islands of Polynesia. The floor of its western division is formed of an alternation of submerged platforms and narrow trough-like depressions. The most southerly of its platforms supports the islands of New Zealand; the central platform is the prolongation of the partially submerged area of the East Indian Islands; the most northerly extends as far as the Sandwich Islands. The trough-like hollows and pit-like depressions between these platforms are of great depth and remarkable irregularity of form. The deepest of these hollows ranges from south-west to north-east, roughly parallel to the islands which fringe the Asiatic continent. It includes three interior abysses, which are the most profound depressions yet detected on the ocean-floor. The depression off the Ladrone Islands has a measured depth of 27,450 feet; that off the Kurile Islands one of 27,930 feet; while, according to observations made by the officers of the American navy, the depression in the neighbourhood of the largest island

of the Japanese group has been estimated at 30,000 feet in depth.

119. Respecting the *nature of the sea-bed*, and the materials of which it is composed, comparatively little was known till recent years, when improved sounding-apparatus and more systematic surveys were adopted. The Mediterranean, for example, in the western portion, consists of sand and shells; in the eastern, of impalpable mud and comminuted shells; and in the Adriatic Gulf, partly of mud and partly of calcareous rock, enclosing shells, which are sometimes grouped in families. The German Ocean, according to Mr Stevenson, is traversed by extensive banks, one of which, occupying a central position, trends from the Firth of Forth in a north-easterly direction to a distance of 110 miles; others run from Denmark and Holland upwards of 105 miles to the north-west; while the greatest of all—the Dogger Bank—extends for 354 miles from north to south. The upper portion of these banks, which occupy fully one-fifth of the whole area of the German Ocean, consists of fine and coarse silicious sands, mixed with comminuted corals and shells. Of late years most valuable additions have been made to our knowledge of the varied sedimentary deposits which cover the bottom of the great ocean-basins of the globe, especially by the recent dredgings of the Porcupine, Lightning, and Challenger, and altogether open up a new field of life and speculation to biologists. From the extended observations made during the recent Challenger expedition, it appears tolerably certain that the sediments which are at present being deposited upon the ocean-floor of the globe arrange themselves into three main groups—the coarse deposits of the shore, the soft muds or *oozes* of the intermediate depths, and the impalpable clays of the deepest abysses. The *shore-deposits* are composed of the stones, sand, and mud brought down to the sea by rivers, or washed off the sea-cliffs by the action of the waves. This material is all deposited in the neighbourhood of the present coast-lines. The stonier and heavier matter is distributed along the edge of the coast-line itself, the sands are swept out into deeper water, while the very finest muds are carried some distance out to sea. It is very doubtful, however, if any notable quantity of these land-derived sediments is carried as much as 200 miles from shore. In all probability the shore-deposits form a mere coast-fringe to our mainland areas, of a breadth varying from 50 to 150 miles. Outside this fringe of shore-deposits, and occupying those enormous areas of the ocean-floor which vary from one to two and a half miles in depth, are found the *Deep-sea Oozes*. These consist of fine muds, generally

white in colour, and when dried resembling powdered chalk. The most widely distributed of these pale muds is the well-known Globigerina Ooze, which covers vast spaces in the Atlantic, Pacific, and Indian Oceans. It contains from 40 to 80 per cent of carbonate of lime, and is almost entirely made up of the microscopic shells of a single genus (*Globigerina*) of the group of the foraminifera. These creatures live near the surface of the ocean, their shells (which are so minute that 15,000 occupy the space of a square inch) sinking to the bottom after the death of the animal. In the Antarctic Ocean, south of the Cape of Good Hope, the place of the Globigerina ooze of the Atlantic is taken by a silicious ooze (*Diatomaceous Ooze*), formed of the remains of similarly minute microscopic plants (*Diatoms*). In the deepest areas of the central Pacific another silicious ooze is met with (*Radiolarian Ooze*), formed of the shells of microscopic animals closely allied to the foraminifera, but having silicious shells, and existing at all depths in the ocean. In descending to depths exceeding two and a half miles, the calcareous shells of the Globigerina ooze are found gradually to grow more and more decayed, and finally to disappear altogether, and the floor of the most profound depths of the ocean is covered by the very distinct *Abyssal Clays*. These are of a deep purple, chocolate, or dull brownish-grey colour, and are generally wholly destitute of calcareous matter. The actual derivation of the material of these abyssal clays is not yet satisfactorily determined; but it has been suggested that it is in great part identical in origin with the Globigerina ooze already described, being similarly derived from the remains of the calcareous foraminifera living upon the surface of the ocean. The lime forming the main mass of these shells is supposed to be dissolved by the excess of carbonic acid known to occur in the sea-water at these extreme depths, and the red clay is supposed to be made up of the non-calcareous residue. Great force is given to this opinion by the fact that when the Globigerina ooze is treated with acids, the residue is almost identical with this coloured clay. It is believed, however, by Mr Murray of the Challenger, that the abyssal clay is derived also in great part from the disintegration of pumice, which is found floating in small quantities upon the surface of the ocean in all regions, and fragments of which occur in more or less abundance in the red clay itself. The inconceivable slowness of the gradual accumulation of this deposit not only follows of necessity if this be actually its mode of origin, but it seems to be placed wholly beyond question by the fact that the half-fossilised bones and teeth of extinct fishes have been found to lie in many areas almost unburied upon its surface, preserved

from complete dissolution by a coating of the black oxide of manganese, possibly derived from the volcanic products already referred to; while the red clay itself contains an abundance of minute specks of iron, like those occasionally collected off the surface of long-frozen snow, and which are supposed to be the dust of shooting stars.

Temperature, Colour, Luminosity.

120. Respecting the *temperature of the ocean*, all our trustworthy information is of recent date, and much remains to be discovered as regards its various areas and its successive depths. We know, however, that it is more equable than that of the land, and that, though the superficial portions are colder in summer than the surrounding atmosphere of any contiguous terrestrial district, they are in winter always several degrees higher—thus exercising the function of a great storehouse of heat for modifying and equalising the climates of the adjacent land. This arises from the high *specific heat* of the waters of the ocean, as contrasted with that of the rocky substances of which the land-surface is composed. It is calculated that four times as much heat is necessary to raise water to the same temperature as the land. As a greater amount of heat is thus required to warm the water up to the same point as the land, so a greater amount must be given off before it can be reduced to the same temperature. The surface temperature is necessarily highest along the equator—or rather along a belt, varying from 2° to 8° , on either side of the equator—and thence gradually diminishes as we approach either pole. Along this equatorial zone, temperatures have been found ranging from 78° to 85° —higher exceptional temperatures (87° and 88°) having occasionally been taken in parts of the Indian Ocean and the Gulf of Mexico. Though varying in *surface temperature* according to latitude—from 80° at the equator to perpetual ice towards either pole—it has yet been found that at very great depths the ocean preserves a pretty uniform but not altogether equable temperature.

The first to attempt a connected account of the distribution of ocean temperature was Sir James Ross, who, from experiments conducted by himself in his Antarctic voyages, drew the following conclusions:—The circle of the mean temperature of the ocean in the southern hemisphere lies between the 56th and 59th parallels of latitude; along which belt the uniform temperature of $39\frac{1}{2}^{\circ}$ was thought to prevail at all depths, from the sur-

face downwards. To the south of this line, owing to the absence of solar heat, the surface depths are colder, and the mean of $39\frac{1}{2}^{\circ}$ is not reached in the 70th parallel till we descend to the depth of 4500 feet, beneath which to the greatest depths the temperature is uniformly at $39\frac{1}{2}^{\circ}$, while the surface temperature is only 30° . To the north of the line of mean temperature, in consequence of the absorption of the sun's heat, the surface depths are warmer; and in the 45th parallel the mean of $39\frac{1}{2}^{\circ}$ is not reached till we descend 3600 feet; while at the equator we have to descend 7200 feet before the same mean is obtained, and then at all depths below this it maintains the unvarying mean temperature of $39\frac{1}{2}^{\circ}$, though the surface is at 80° . Presuming that a similar order prevails in the northern hemisphere, we have thus three great regions of oceanic temperature—an equatorial and two polar, the former characterised by warm water at the surface, and the latter by cold.

This generalisation of Sir James Ross has recently been wholly disproved by the experiments of Drs Carpenter and Wyville Thomson on board the *Porcupine* and *Lightning* during the summers of 1868-69-70, when surveying (dredging and sounding) in the North Atlantic. Instead of finding at great depths a uniform temperature of $39\frac{1}{2}^{\circ}$, they ascertained that in some areas the thermometer fell to 30° and 29° (or that of ice-cold water), while in other areas it rose to 44° and 46° ; thus showing that in the region within and beyond the Faroe Islands at least, there were colder and warmer reaches of sea-water. These facts were subsequently corroborated by the more protracted experiments of the *Challenger* expedition. At a depth of about 500 fathoms over the greater part of the regions surveyed, the temperature of the water of the ocean-basins was ascertained to be tolerably uniform, varying from 40° to 45° Fahr. Below this line the temperature sinks very slowly and gradually, until in the deepest areas it descends even below the freezing-point of fresh water (32°). In other words, the great ocean-basins are filled to four-fifths of their total capacity with water of a temperature only a few degrees above the freezing-point. This cold water is apparently derived from the polar oceans, almost entirely from the Antarctic, and creeps gradually over the ocean-floor in the direction of the equator, where the line of 40° Fahr. approaches within 300 fathoms of the surface, and the bottom temperature is occasionally as low as 32.7° . The temperature of the ocean waters, above the line of 500 fathoms, varies with the locality, and seems to be dependent upon conditions of latitude, prevalent winds, currents, and the like, and varies from an extreme of $83\frac{1}{2}^{\circ}$ under the equator, to

below the freezing-point in high latitudes. This generalisation, however, must be regarded as merely approximative. The depth of the superficial and heated stratum of water is much greater in the north than in the south Atlantic—the datum line of 40° being reached at a depth of a mile or more in the latter, while in the former it occurs at a depth of about half a mile. This exceptionally high temperature of the north Atlantic is possibly a result of the influx of the super-heated waters of the current of the Gulf Stream. Again, in certain local depressions of the ocean-floor the temperature of the sea is found to decrease in the normal manner to a certain depth, beyond which it remains without further change to the bottom. This has been explained by the theory that the abyssal waters in these depressions are cut off from the general circulation, the margin of the basin they occupy being elevated above the lowest horizon of ocean temperature; the constant temperature of the waters of their lower depths being that of the deepest stratum of polar water which is able to make its way over the margin. Thus in the partly enclosed China, Sulu, and other seas to the east of Asia, the minimum temperature is met with at 500 or 600 fathoms, and remains constant to the bottom; this minimum temperature apparently affording an index of the height of the rocky barrier separating these basins from the ocean depths. We have a striking example of the same phenomenon in the N. Atlantic. The deep waters filling its two great depressions have a uniform temperature of 35° below a depth of 2000 fathoms—that being the height of the ridge preventing the influx of the much colder Antarctic waters from the south. The depression off the coast of Brazil, on the other hand, being open to the southward, has its bottom water reduced to a temperature of 33° Fahr.

121. Such are the facts, so far as ascertained, respecting the general temperature of the ocean; but inland seas and currents may be colder or warmer according to the position they occupy and the direction in which they proceed. The surface temperature of the Gulf of Mexico, for example, is several degrees warmer than the main Atlantic under the same latitude; the waters of the Gulf Stream are also several degrees higher in a large portion of its course than those through which it flows; while the Arctic Current, on the other hand, is considerably colder. Of inland seas, the Mediterranean is the only one whose temperature has hitherto been carefully studied. In this enclosed area the limit of invariable temperature is met with at a depth of about 100 fathoms. At this horizon a temperature of 54° or 55° is met with and remains constant to the bottom, even where the waters exceed

12,000 feet in depth. Above this 100-fathom line there is a rapid rise from 54° to a maximum temperature of 78° upon the surface. This curious uniformity of temperature of the waters at great depths in this sea is easily explained by the fact that its interior hollows are cut off from the general ocean circulation, the shallowness of the Strait of Gibraltar preventing the entry of the cold polar water into the basin. The temperature of the waters in its depressions appears to be identical with that characteristic of the crust of the earth in the neighbouring countries. Contrasting the temperature of *inland seas* with that of the *outer ocean*, "it may be regarded as a general rule," says a high authority, "that all inland seas, at great depth, represent nearly the mean temperature of the earth in the latitude where they are situated; whilst in the ocean, the low temperature of the bottom in every latitude is produced by the cold currents setting in eternally from the polar regions."

122. Besides the preceding conditions of saltness, density, depth, and temperature, there are also those of *colour* and *luminosity*, usually adverted to by navigators and geographers. In small quantities water is generally regarded as colourless, but that of the ocean assumes different hues, and this altogether independent of the colours of the sky which may be mirrored on its surface. Thus, in the open ocean, shallow water is indicated by a *green tint* of different degrees, while profound depths are characterised by an *indigo blue*—a colour induced, according to Professor Tyndall, by the refraction of light by the infinitesimally small particles which remain suspended in the waters. Of course, in some localities there may be accidental or even permanent discolorations, arising from the entrance of river-water, from peculiarity of bottom, or from the presence of countless myriads of vegetable and animal organisms; hence the application of such terms as Red, Black, White, Yellow, Green, and Vermilion to certain seas and areas of the ocean. In general, however, the ocean water is clear and limpid, and, under favourable circumstances, objects are reported to have been seen at a depth of 300 and 400 feet, or about half the distance to which the sun's light is supposed to penetrate into the abyss of waters. Such reports, however, must be received with caution; for, from the experiments made by M. Cialdi and Father Secchi in the Mediterranean during April 1865, we learn that the greatest depths at which a white disc, 11 feet in diameter, could be seen, even under a vertical sun, was only $151\frac{1}{2}$ feet.

123. The phenomenon of luminosity or phosphorescence is less general, perhaps, and seems to depend in a great degree on locality,

season of the year, and state of the weather. Luminous creatures of various kinds, as well as decaying animal matter in solution, appear to be the proximate cause of the phenomenon, which becomes more apparent in still, dark nights, and where the surface of the water is disturbed by the stroke of an oar, or the friction of a passing keel.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter attention has been directed to the main natural divisions of the ocean ; and to the composition, density, depth, temperature, colour, luminosity, and other physical characteristics of their waters. The divisions of the ocean into Pacific, Atlantic, Indian, Arctic, and Antarctic areas, are sufficient for the ordinary purposes of description ; and the nomenclature of their various ramifications after some discoverer, position, adjacent country, colour, or other peculiarity, has been long established in general geography. Their further subdivision into *zones*, *belts*, *regions*, and the like, comes under the consideration of Climatology rather than of Hydrography ; and the technicalities (bays, gulfs, straits, creeks, &c.) by which their minor sections are distinguished, have been already noticed in par. 42. Their dimensions are matters merely of measurement and calculation ; their composition, depth, temperature, and the like, are subjects for experiment and observation.

Occupying different positions on the earth's surface, and having different configurations, the oceans and seas, properly so called, are necessarily characterised by different physical and vital conditions. The Pacific, almost shut out from the influences of the Arctic Ocean, is in a different condition from the Atlantic, which communicates freely with the north ; while the Indian Ocean, encircled on three sides by land, and lying largely in the torrid zone, presents external conditions differing widely from either. All three open broadly to the great Southern Ocean, from which they receive the primary impulse of their tides and currents ; but while the Indian and Atlantic are deep and free, the Pacific is largely obstructed by reefs and islands. It should also be borne in mind that the main oceans, like the great continents, lie meridionally, or at right angles to the equator, and are thus prevented, by the intervention of the land, from receiving in their winds tides, and currents, the normal effect of the earth's daily rotation.

Though differing slightly in different areas, the composition of sea-water is, on the whole, very equable, and $3\frac{1}{2}$ per cent of saline ingredients may be set down as the general average. Along the courses of the trade-winds, in circumscribed seas, and other similar areas subjected to active evaporation, this percentage may be slightly increased ; while in others it may be correspondingly decreased by periodical rainfalls, by the melting of polar ice, or by the influx of large and rapid rivers. The average density of sea-water, as compared with pure water at 62° Fahr., is 1.0275 ; and this density, corresponding as it does with an average saltiness of $3\frac{1}{2}$ per cent, will decrease where the water is fresher, and increase where it becomes salter, than the general average. This saltiness and density renders the ocean less vaporisable than fresh water, and also keeps it longer from freezing—the freezing-point of fresh water being 32° Fahr., while that of sea-water is $28\frac{1}{2}^{\circ}$. This composition is all-essential to the wants of its plants and animals ; and though the rivers are incessantly carrying in fresh accessions of saline matter, the equilibrium is ever maintained by these wants, as well as by the chemical interchanges that take place among its sediments.

The average depth of the ocean is estimated at 3 miles, and reliable soundings have been taken at nearly $5\frac{1}{4}$ miles ; but, as a large portion is much under the general average, it is highly probable that some of its recesses may sink to the depth of 8 or 10 miles. So far as we know, the ocean-bed has its deeps and shoals, its pits and precipices, its troughs and ridges, in all probability like the surface of the dry land. In fact, it is nothing but the submerged surface of former lands, the crust-elevations forming the dry lands, and the crust-depressions filled by the waters of the ocean, gradually but irregularly interchanging their positions in the progress of long geological ages. A knowledge of these depths—or rather of the shoals and irregularities of the ocean-bed—is of vast importance in geography, at the same time that it is all-essential to navigation. The safety of the commerce of the civilised world depends upon correct chartography ; these deeps and shallows determine the direction of currents, and inset and velocity of tides ; and marine life is visibly regulated both in its dispersion and numerical amount by depth and mineral conditions of sea-bottom.

The surface temperature of the ocean varies of course with the latitude, being highest at the equator, and gradually decreasing towards either pole. In the torrid zone temperatures varying from 78° to 88° have been noted, and from these maxima it declines irregularly, stage by stage, to the perpetual frost of the

polar regions. On the whole, the water of the South Atlantic is heavier and colder than that of the North, and so also is that of the South Pacific compared with that of the North, though in a less marked degree. In the torrid and temperate zones the heat of the water declines rapidly to a depth of about 500 fathoms, where there is found to be a uniform temperature of about 45° . Below this invariable horizon the temperature sinks very slowly to the bottom. Where the depth is greater than 2000 fathoms, the temperature of the bottom layers is slightly above the freezing-point of fresh water (32° Fahr.); in the most profound depths it occasionally falls below it. It must be borne in mind, however, that this normal temperature is greatly interfered with by surface-drifts and deep-sea currents—some areas being colder and some warmer, according to the direction from which or to which the current flows.

Colour, luminosity, and the like, are generally local and seasonal peculiarities—depending upon the presence of mineral or organic impurities which may occur in one area and not in another, or during one brief season, and yet be absent for the greater portion of the year.

To those who desire more extensive details of the ocean and its physical peculiarities, we cannot recommend them to a more attractive source of information than Captain Maury's 'Physical Geography of the Sea'—a volume replete with reasonings as well as observation, though occasionally impeded by reflections which impair, rather than impart to, the value of its information, while his conclusions have been largely superseded by the results of more recent research. Sir Wyville Thomson's 'Depths of the Sea,' an account of the general results of the dredging cruises of H.M.S. Porcupine and Lightning during the summers 1868-69-70, will also afford important information touching the physical and vital conditions of the deeper parts of the ocean to which it refers; while for the most recent developments of this great subject, the student should study the same Author's work, 'The Atlantic,' and the numerous scientific papers treating of the discoveries of the Challenger, and other recent exploring expeditions.

IX.

THE WATER—ITS OCEANS AND OCEAN-CURRENTS.

Waves—their Height, Velocity, and Impact.

124. LIKE other fluids whose particles are free to yield to every impulse, the waters of the ocean are subject to several movements, the more important of which are waves, tides, and currents. Waves are produced by winds, and occasionally by earthquake commotion; tides by the attractions of the moon and sun; and currents chiefly by that incessant tendency which waters of different densities and temperatures have to assume a state of equilibrium. And, first, of WAVES, whose main characteristics are magnitude, velocity, and force of impact. Waves occur in every part of the ocean, and wherever the wind blows—the friction of the aerial current on the surface of the waters produces undulations, which increase, according to the power of the propelling force, from the gentlest ripple to billows 30 or 40 feet in height. In deep and open seas a continuous wind produces merely an undulation, or up-and-down movement of the surface waters; and this commotion, even in the case of a wave a quarter of a mile in breadth and 40 feet high, is not sensibly felt at a depth of 220 fathoms. But in obstructed and shallow seas the lower part of the advancing undulation is retarded by frictional contact with the bottom—the upper portion advances with headlong motion, and ultimately breaks with forcible impact on the opposing shore, which is worn and abraded by the backward and forward motion of the surf. Such is the beginning, course, and termination of ordinary waves,—at first a mere ripple; as the gale increases, a long roll and swell in the deep sea; and ultimately, a cresting and dash of breakers on the shelving shore. Occasionally, however, the wind shifts, and sets in waves from opposite directions, and these crossing and commingling produce

a violent commotion, even far out at sea, and in the deepest waters.

125. The aspects and characters of waves are known to sailors by many different names; the ruffle or ripple under a rising breeze being spoken of as a *catspaw*, the long undulation as a *swell* or *billow*, the shorter undulations as they approach the shore as *rollers* and *breakers*, and the broken water along shore as *surf*. The big heavy waves that occasionally set in when there is no wind (having been produced by storms far out at sea) are said to form a *ground-swell*; the commotion produced by cross-waves forms a *chopping sea*, and in a less degree a *jabble* or *cross-lipper*; but these and similar terms belong more to nautical technicality than to the generalities of Physical Geography. In circumscribed and shallow seas waves are short and abrupt; in the open ocean they assume the character of a long rolling swell. Whatever diminishes the friction of the wind—packs of ice, floating sea-weed, oil, and the like—suppresses the rise of the waves; and even during fogs and rains the sea is not so rough as in dry weather, in consequence of the diminished attraction of the atmosphere for water, and necessarily lessened concomitant friction.

126. Generally speaking, the magnitude of *wind-waves* has been greatly exaggerated, partly from the difficulty of making correct observations, and partly from the impression of dread produced on the mind of the observer. The greatest waves known are said to be those off the Cape of Good Hope, where, under the influence of a north-west gale, they have been found to exceed 40 feet in height. Off Cape Horn they have been measured at 32 feet from trough to crest; and in the North Atlantic, waves from 20 to 25 feet are by no means uncommon; while waves of even 43 feet in height have been measured in stormy weather. In the Bay of Biscay, during violent gales, they have been known to attain a height of 36 feet. In the winter of 1870, the waves which broke down the breakwater at Wick were estimated at 40 feet high—having risen, it is said, from 25 to 30 feet above the parapet, which is 20 feet above high-water level. In British seas, however they rarely exceed 10 or 12 feet; and all accounts of their running “mountains high” must be received as mere poetical exaggerations. In the case of *earthquake-waves* the conditions are altogether different; and as the whole mass of water is then thrown into commotion by sudden and abrupt risings, fallings, and whirlings, waves, or rather walls of water, 60 or 80 feet high, may be thrown with tremendous impetus upon the land. In the Lisbon earthquake of 1755, the destructive wave that rolled in upon the coasts of Portugal was estimated at 60 feet; in the

Simoda (Japan) earthquake of 1854, three huge waves, at intervals of a few minutes, rushed into the bay, destroying the native craft, and completely submerging the town of Simoda; and during the earthquake convulsions which visited the coasts of Chili, Peru, and Bolivia in 1868, similar waves were thrown upon the shores, carrying the shipping hundreds of yards inland, and leaving it high and dry at various elevations.

127. The velocity of waves depends primarily, of course, upon the power and continuance of the wind, but is greatly modified by, and bears an ascertainable relation to, their magnitude and the depth of the water over which they travel. Thus it has been calculated by Professor Airy that a wave 100 feet in breadth and in water 100 feet deep travels at the rate of about 15 miles per hour; one 1000 feet broad and in water 1000 feet deep, at the rate of 48 miles; whereas another, 10,000 feet in breadth and in water 10,000 feet deep, will sweep forward with a velocity of not less than 154 miles per hour. This relation between the breadth of a wave, its velocity of progress, and the depth of the water in which it travels, has been embodied by Mr Airy in the following table:—

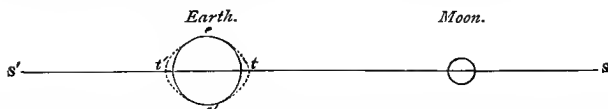
Depth of Water in Feet.	Breadth of the Wave in Feet.							
	1	10	100	1000	10,000	100,000	1,000,000	10,000,000
	Corresponding Velocity of Wave per Second in Feet.							
1	2.262	5.320	5.667	5.671	5.671	5.671	5.671	5.671
10	2.262	7.154	16.883	17.921	17.933	17.933	17.933	17.933
100	2.262	7.154	22.264	53.300	56.672	56.710	56.710	56.710
1,000	2.262	7.154	22.264	71.543	168.830	179.210	179.210	179.230
10,000	2.262	7.154	22.264	71.543	226.260	533.900	566.720	567.100
100,000	2.262	7.154	22.264	71.543	226.260	715.430	1688.300	1793.300

128. The force with which a wave strikes against any opposing barrier depends, in like manner, upon its bulk and velocity; and in the case of huge waves this impact is enormous. From experiments made at lighthouses and breakwaters, their effective pressure during severe storms has been estimated as high as 6000 lb. per square foot; and one has only to observe the breaches occasionally made in sea-walls, and the distance to which blocks of stone, several tons in weight, have been hurled forward, to be convinced of their great propulsive power. Of course the force with which a wave simply *strikes* is not to be altogether estimated by its propulsive power, for substances submerged in water lose a certain portion of their weight, which greatly facilitates their displacement and transport.

Mr Stevenson, in his experiments at Skerryvore Lighthouse (Western Hebrides), found the average force of the waves for the five summer months to be 611 lb. per square foot; and for the six winter months, 2086 lb. He mentions that the Bell Rock Lighthouse, 112 feet high, is sometimes buried in spray from groundswells when there is no wind; and that on November 20, 1827, the spray was thrown to a height of 117 feet—equivalent to a pressure of 6000 lb., or nearly three tons per square foot.

Tides—their Origin and Influence.

129. The next, and perhaps the most important and persistent of oceanic movements, is that of the **TIDES**—a term applied to the periodic rising and falling of the waters, occasioned chiefly by the attraction of the moon, but partly also by that of the sun. In obedience to the universal law that “every particle in nature attracts every other particle with a force inversely as the square of the distance,” the earth is attracted by the sun and moon, but more by the latter in proportion to its greater proximity. Land and water alike experience this attraction, but the particles of the latter being free to move among themselves, the mass of the ocean is drawn out beyond its normal circumference towards the attracting bodies. Had the earth been immovable as regards the sun and moon, this bulging out of the waters would have been stationary; but as she turns on her axis, meridian after meridian is brought directly opposite to the attracting force, and thus the rising of the waters becomes a great *tidal wave* or *flow* that travels round the globe. The moon, we have said, exercises the greater attraction (her attraction being to that of the sun as 100 to 38), but when the sun and moon are in conjunction, or in opposition (that is, at new and full moon), the sum of the two attractions will cause the greatest possible rise, known as *spring-tides*; and when the moon is in her quadratures (that is, at her first and last quarters), the sun’s attraction, acting in a different direction, will diminish the lunar tide, and then we will have the least rise, or *neap-tides*. The following diagram may assist the comprehension of these phenomena:—



Here *t* being the nearest point of the earth’s surface to the moon, the waters at that part are most attracted towards that luminary,

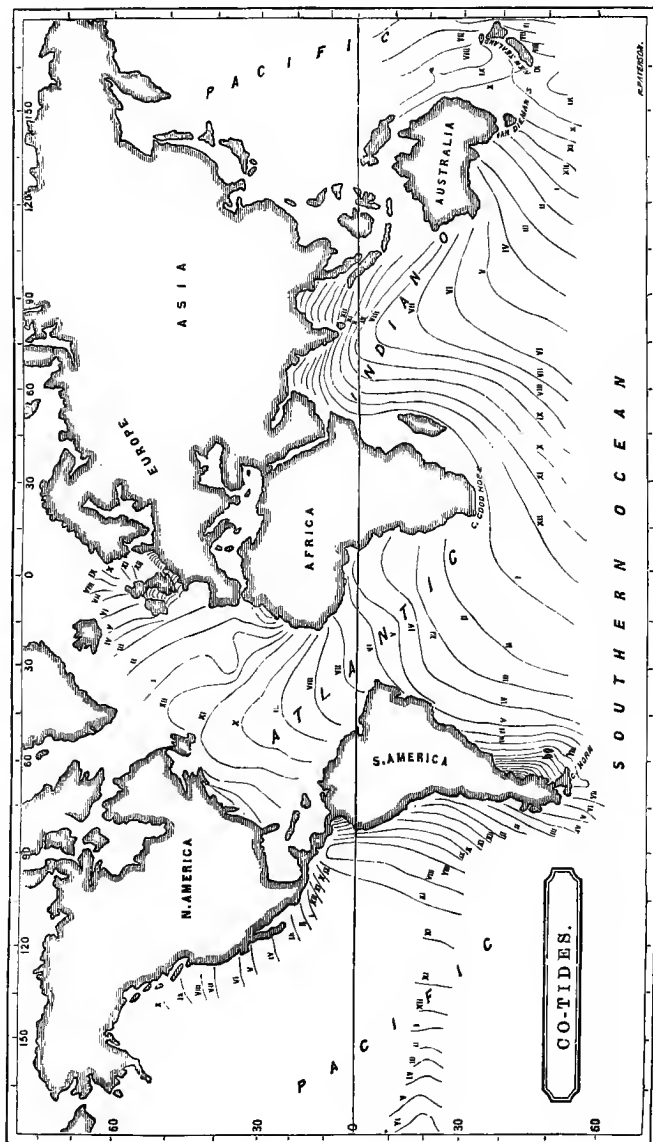
and of course rise highest ; while on the opposite side at t' the earth is drawn, as it were, away from them, and they stand out nearly at the same height as those at t . But as the waters rise simultaneously at t t' they are drawn away from e e' , and as the earth turns round, each point on its surface will necessarily have two high-waters and two low-waters per day. In other words, the sea *flows* or rises as often as the moon in her apparent circuit passes the meridian, both the arc above and the arc below the horizon, and *ebbs* or falls as often as she passes the horizon, east and west. The solar day, however, being only 24 hours, and the lunar (owing to the moon's monthly course round the earth) being 24 hours, 54 minutes, it requires rather more than a rotation of the earth to bring the same meridian to the same position relatively to the moon, as it had the preceding day. In other words, it requires more than 24 hours to bring the moon round to its vertical position over any given place, and thus the tides of one day are always about an hour later than they were on the preceding day. Again, had the moon been the sole attracting body, the tides would have risen always to the same height ; but the sun, exerting a simultaneous attraction either along with or against that of the moon, creates an alternate maximum and minimum of flow. Thus, when the sun is at S and S' his attraction is combined with that of the moon, and a higher tide is the result. When at S the darkened side of the moon will necessarily be towards the earth, and it is new moon ; and when at S' the illuminated face of the moon will be towards the earth, and it is full moon ; so that the higher or *spring-tides* take place alternately at new and full moon. On the other hand, when the moon is 90° from the sun's place (that is, when she is in her first and last quarters, or half moon), his attraction, being exerted at right angles, counteracts that of the moon, and the result is the lower or *neap-tides*—the proportion of spring to neap being as 138 to 62, or nearly as 7 to 3. The *height* and *time* of the tides thus vary with the moon's age ; and this being known, their recurrence and culmination at any given spot can be calculated with the greatest exactitude. The greatest tides occur, of course, when the luminaries are nearest and pass most vertically to the place of observation ; and as each tide has only about six hours to *flow* and about six hours to *ebb*, the highest must necessarily be the *swiftest*, and the lowest the *slowest*.

130. Such, in general terms, is the theory of the tides ; and had the surface of the globe been entirely covered with water, the tidal wave would have been regular and continuous from meridian to meridian, and, as a consequence, highest in the region of

the equator, and gradually falling away towards either pole. But the continuity of the ocean being interrupted by land, and this land lying in a great measure meridionally, as well as being irregular in outline, and consisting in many parts of islands, the course of the tidal flow is obstructed, and deflected into various courses. Under the present arrangement of sea and land, these courses are, however, sufficiently persistent; and thus their directions, times, velocities, and heights, can be determined with accuracy for the purposes of navigation. The Southern Ocean, encircling the globe, and being comparatively uninterrupted by land, may be regarded as the area in which the tidal wave receives its great primary impulse. It is thence carried forward, deflecting itself northward into the Indian, Atlantic, and Pacific Oceans, where, uniting with the minor tide-waves generated in these expanses, it flows, rises, and subdivides, according to the outline of the coasts, the depth of water, and the obstruction of islands.

131. Notwithstanding the complications arising from these causes, there is still great regularity in the bi-diurnal flow and ebb of the tides; and by noting the times at which the same high-water reaches different parts of the coast, a series of lines connecting these points may be laid down so as to indicate the course of the tidal wave with great precision. Such a series of lines are termed *co-tidal lines*, or lines of simultaneous tide, and mark the progress of the summit of high-water from its origin in the Southern Ocean to its remotest ramifications in northern waters. We say northern waters, for though the primary and normal direction of the tidal wave is from east to west, in obedience to the apparent course of the sun and moon, yet, on entering the troughs of the Indian and Atlantic Oceans, it is compelled to assume a northerly course in accordance with the configuration of these seas. Thus the new or full moon high-water that passes Van Diemen's Land every morning at twelve, takes twelve hours to reach Ceylon, and thirteen to reach the Cape of Good Hope; in another twelve hours it has passed up the Atlantic, and arrived at Newfoundland; at the end of the third twelve it has rounded the north of Scotland, and is opposite to Aberdeen; at the fourth twelve, or at midnight of the second day, it is opposite the mouth of the Thames; and it is "not till the morning of the third day that this wave fills the channel of the Thames, and wafts the merchandise of the world to the quays of the port of London." (See Map of *Co-tidal Lines*.)

132. The tides, we have said, may be regarded as taking their rise in the uninterrupted expanse of the Southern Ocean. As the



wave proceeds westward, it is deflected northward broadly into the Indian Ocean, rapidly and deeply into the larger channel of the Atlantic, and slowly and feebly into the Pacific, where its course is obstructed by numerous islands and coral-reefs. The *velocity of the tidal wave* depends primarily on the conformation and depth of the ocean—proceeding with the greatest rapidity where the ocean is freest and deepest. As the co-tidal lines are laid down at hourly distances, they afford a pretty correct estimate of the tidal velocity—the wider the lines (that is, the greater the distance travelled over in one hour) the greater the speed, and the closer the lines the slower the rate of progress. In the free depths of the Southern Ocean this velocity may equal 1000 miles per hour, while in restricted seas like the North Sea the rate is scarcely a twentieth of that amount. As the tidal wave differs from a wind-wave in not being a mere undulation, but a wave of translation, its *height* in any sea will depend mainly on the configuration of the shore, the form of bottom, and the direction in which it is propelled. In the open expanse of the Southern Ocean, as well as over a large portion of the Pacific, the tidal wave rarely exceeds five or six feet, and in the Indian and Atlantic Oceans perhaps eight or ten; but in bays and gulfs opening broadly to its course, and narrowing towards their interior recesses (such as the Bay of Bengal, our own Bristol Channel, and the American Bay of Fundy), it may rise to 20, 30, or, under favourable circumstances, even to 50 or 60 feet in height. And where such seas terminate in river-estuaries, the wave, still converging, forms a high head or wall of water, termed a *Bore*, which ascends the river with sudden and destructive impetuosity. Such are the tidal-bores of the Tsien-tang, which are said to extend across the river 30 feet high, and ascend with a velocity of 25 miles per hour; of the Hooghly, 20 and 25 feet high; of the Sakerang, in Borneo, which rises 10 feet high from bank to bank, and breaks in twelve or fifteen huge rollers in succession of equal height and force: of the Garonne, 10 and 12 feet; the Severn, 9 feet; the Amazon, 12 and 13 feet; and other rivers whose gradually narrowing estuaries are exposed to the concentrated incidence of the tidal wave. On the other hand, inland seas and gulfs whose openings are narrow, and lie transversely to the course of the tidal wave (as the Mediterranean and Baltic), experience little or no rise, and are next to tideless. Not only is the primary wave that sets up the Atlantic excluded from such seas, but their own areas are too limited to admit of the formation of any perceptible tide-wave of their own; and thus, for all practical purposes, strictly inland seas and lakes may be considered as tideless.

Speaking of the Tsien-tang, the destructive impetuosity of whose tidal-bore has often been described by travellers, a friend (T. T. M.), writing from China, says : " The bore gives it a peculiar interest, but spoils it as a commercial river ; and yet the Chinese do ascend it. The pilots anchor just below where the bore begins to form, and then wait for a steady favourable wind. Immediately on the tide-wave passing upwards, they weigh anchor and chase the bore, as it were, to escape from its successor. In this manner they push on till they reach an upper portion of the bore-tract, where it has fallen to two or three feet of vertical height, and is no longer dangerous to such craft as are prepared to meet it. This bore is always highest about the autumnal equinox, when the governor of the province (Tche-Keang) goes down in great state to the banks, and throws into the river offerings of fruits and flowers."

133. The mechanical effects of the wind-waves are felt chiefly along the shore-line in their battering, wearing, and abrading action ; the tide-waves, on the other hand, in shallow seas and narrow gulfs, act more like currents, which, in their ebb and flow, are ever transferring, arranging, and reassorting the sediments of the ocean. The wind-wave merely breaks upon the bars of rivers and renders their navigation dangerous ; the tidal wave, by its influx, fills the river-channel and renders it navigable, and by its efflux scours out impurities, and carries them forward into the general reservoir of the ocean. The wind-wave may be stilled, and the surface of the ocean be as smooth as a mirror ; while it is driven from one coast it may impinge on another ; or the wave from one direction may counteract that from another : but the ebb and flow of the tidal wave is regular and incessant, and in its direction, time, height, velocity, and power, will continue the same while sea and land remain undisturbed in their present relations.

Currents—their Causes and Functions.

134. We now proceed to what are termed the CURRENTS of the ocean—movements which, like great rivers, are ever transferring the waters from one region to another. They form, in fact, the circulatory system by which the ocean is maintained in a state of equilibrium. As to their actual causes, scientific men are not fully agreed. By Dr Carpenter and others it is believed that they depend primarily upon the unequal temperatures and densities of different zones of the ocean, and the unequal evaporation sus-

tained by these zones, which modifies the directions imparted by the primary causes. Wherever we have waters of different temperatures, or, what is the same thing, of different densities, there the lighter will ascend and the heavier descend ; and wherever a deficiency takes place through evaporation, there the waters will flow in from the adjacent parts to make up the deficiency. But differences of density may also arise from different degrees of saltiness, and wherever the saltier water subsides and flows off as an under-current to some fresher region, there at the same time will the fresher and lighter flow in from above to restore the equilibrium. By Dr Croll and others it is contended, on the other hand, that the grander currents owe their origin solely to the action of the prevailing winds, which force the surface waters before them in certain regions, and that the movement thus established necessarily draws the remaining waters into the general circulation. But whichever theory we accept, if we bear in mind that the continuity of the ocean is interrupted by continents and islands, reefs and shoals, and further disturbed by local winds and periodical variations of temperature, it will readily be seen why its currents should assume different characters and courses. In fact, the currents and counter-currents of the ocean are extremely complicated ; and though the courses of some of the main streams are intelligible enough, there remains very much to be done in this department of Hydrography.

135. It is usual to arrange the ascertained currents into *constant*, *periodical*, and *variable*,—the constant being those arising from the combined influences of unequal temperatures and densities in the waters of the ocean, the rotation of the earth, and the trade-winds ; the periodical, by the tides, the monsoons, and the sea and land breezes in tropical countries ; and the variable, such as may be produced by local peculiarities in the tides and winds, the melting of ice in polar regions, and other similar causes. It is also customary to speak of *drift currents*, and *deep-sea currents*,—the former due to the long-continued agency of the wind, and only affecting the waters to a trifling depth—the latter arising from the great primary causes of ocean circulation above alluded to, and extending their influence hundreds of fathoms beneath the surface. In like manner, it may be useful to note the distinction between a *marine*, or upper current, and a *sub-marine*, or under current ; between a *current* flowing one way, and a *counter-current* coming from an opposite direction ; and between the mode of naming winds and water-currents,—the former being named after the direction *from* which they blow, as a “west wind” (that is, one blowing from the west)—and the latter after the direction

to which they are flowing, as an "easterly current," that is, one flowing towards the east.

136. The constant and deep-sea currents being the more important, it is to these that we would mainly, and in the first place, direct attention. As already mentioned, the heat of the torrid zone, by warming the equatorial waters, renders them lighter, and occasions a greater evaporation there than in any other region—perhaps from 12 to 16 feet per annum; and as a consequence, the waters of the polar regions, being heavier, set in chiefly as under-currents, while, at the same time, an abyssal body of ice-cold water of enormous depth creeps along the bottom of the ocean both from the north and the south towards the equatorial regions. Here the united waters growing warmer and warmer, gradually rise to the surface, where they come under the influence of the trade-winds. These force them swiftly onwards in a westerly direction in the form of the well-known equatorial currents; in which a portion is evaporated, while the remainder overflow as warmer and lighter surface-currents northwards and southwards to either pole, again to become colder, and again to find their way to the equator in incessant circulation. From these four primary flows—the two from the poles towards the equator, and the two from the equator towards the poles—arises the great circulatory system of the ocean, which is modified and broken up into a number of minor currents by configuration of coast, form of bottom, unequal reception of heat by different areas, the influx of rivers, and other kindred causes. These various currents, having different directions, volumes, velocities, and temperatures will be better understood, perhaps, by being arranged under the three great oceans—Atlantic, Indian, and Pacific—in which they respectively occur.

137. The principal and better-known currents of the Atlantic are the Equatorial, the Guiana, the Brazil, the Gulf Stream, the Guinea, and the Arctic. Besides these there are some minor drifts and branches, the courses of which will be better understood by reference to the Map (p. 156) than by any amount of description. The *Equatorial*, as the name implies, manifests itself chiefly in the region of the equator, and flows across the ocean from the African towards the American continent. When more than half-way across it shows a tendency to bifurcate into a north-west branch and a south-west branch, and this tendency increases till within 300 or 400 miles of Cape St Roque, when it fairly divides,—sending one main stream northwards by the coast of Guiana into the Caribbean sea—and another, somewhat feebler, southwards along the shores of Brazil. The length of the



Equatorial Current, from the coasts of Africa to the Caribbean Sea, is about 4000 miles ; its breadth at its commencement 160, and where it divides 450 miles ; its velocity is from 20 to 60 miles a day ; and its average temperature about 75° Fahr., or from 4° to 6° under that of the ocean through which it flows. Its southern, or *Brazil* branch, flows at a distance of about 250 miles from the coast (the intermediate space being occupied by variable currents), and at the rate of 25 miles per day ; a rate, however, that is sensibly diminished by the cross stream from the Plata, and which gradually declines till the current ultimately dies away in the Strait of Magellan. The north-west branch of the Equatorial, spreading out as it proceeds and gradually diminishing in speed, ultimately merges into the drift of the north-east trade-winds ; while the *Guiana* section proceeds unimpeded to make the circuit of the Caribbean Sea and the Gulf of Mexico.

138. As it makes the circuit of the Caribbean Sea and the Gulf of Mexico, this western branch of the Equatorial Current acquires more heat, a greater degree of saltness, and that intense blue colour so characteristic of briny waters. With these new acquisitions it leaves the Mexican Gulf, and, pressing through the narrow channel of Florida, becomes the celebrated *Gulf Stream*—of all the Atlantic currents the most wonderful in its character and the most important in its results. Doubling the Cape of Florida, this Gulf Stream (that is, stream from the Gulf of Mexico) flows north-east in a line almost parallel to the American coast ; touches the southern borders of the banks of Newfoundland ; and thence, with increasing width and diffusion, proceeds across the Atlantic, till, in the region of the Azores, it spreads out into two great branches—one curving southwards towards the equator, and the other flowing northwards, impinging in its course against the western coasts of Europe, and ultimately losing itself in the waters of the Arctic Ocean. The length of this great ocean-river from its commencement to the Azores is 3000 miles, and its greatest breadth about 120 miles. When it leaves the Strait of Florida its velocity is about 4 miles an hour ; off Cape Hatteras, in North Carolina, it is reduced to 3 miles ; on the Newfoundland banks it is further reduced to $1\frac{1}{2}$ miles ; and its gradual abatement of force continues with its diffusion across the Atlantic. A similar decrease takes place in its temperature, the maximum of which in the Strait of Florida is 86° , or 9° above that of the ocean in the same latitude. Off Newfoundland, in winter, it is said to be from 25° to 30° above the water through which it flows ; in mid-ocean, from 8° to 10° ; nor is the heat wholly lost when it impinges against the shores of western Europe. The Gulf Stream is thus, in reality,

a great thermal ocean-river, incessantly flowing from warmer to colder regions, diffusing warmth and moisture along its course, and tempering the climates of countries that lie within its influence. Compressed, as it were, at its commencement between two areas of colder water, its deep-blue warm current rises in convexity above the surrounding ocean ; but as it proceeds it cools, becomes diffused, assumes the ordinary level, and partakes of the greener hue of northern waters. It sets a limit to the southward flow and chilling influences of the Arctic iceberg, that melts away in its warm stream, and becomes at the same time the great natural barrier between the life of the Northern and Southern Atlantic.

The investigations of Dr Bache have shown that while the Gulf Stream has a temperature higher than that of the waters on either side, it is also alternately warmer and colder within itself, being made up as it were of distinct streaks of water of different temperatures. The most surprising part of this result is the abruptness of the change along the line where the two great currents meet each other—a change so abrupt that the boundary of the Arctic Current is now technically designated the “cold wall” of the Gulf Stream. So marked, indeed, is this boundary, that in 1861, Admiral Milne, of H.M.S. Nile, on entering the Gulf Stream found the water 70° at the bow, while it was only 60° at the stern. As the Stream flows northward and eastward it gradually widens—being little more than forty miles off Cape Florida, one hundred and fifty miles off Charleston, and more than three hundred at Sandy Hook. As it spreads out, its temperature becomes lower and lower ; but its surface warmth is still well marked at Sandy Hook, and its genial influence is felt even in Britain, and along the north-western shores of Europe onwards to Spitzbergen. The inequalities of the bottom may be appreciated by the soundings off Charleston, where, from the shore to a distance of two hundred miles, the following depths were successively measured : 10, 25, 100, 250, 300, 600, 350, 550, 450, 475, 450, and 400 fathoms. Off Sandy Hook, at successive distances from the coast of 100, 150, 200, 250, 300, 350, and 400 miles, the temperature near the surface, to a depth of thirty fathoms, averaged 64°, 65°, 66°, 64°, 81°, 80°, and 75° Fahr.; at a depth between forty and a hundred fathoms it averaged 50°, 52°, 50°, 47°, 72°, 68°, and 65° Fahr.; and at a depth below three hundred fathoms it averaged 37°, 39°, 40°, 37°, 55°, 57°, 55° Fahr. The rapid rise of the temperature after the fourth sounding indicates the position of the “cold wall,” and the entrance into the waters of the current.

139. The Equatorial Current, flowing westward from Africa to the Gulf of Mexico, and the Gulf Stream, flowing from that gulf

eastward to the Azores, and thence curving southwards, produce a great whirl, as it were, in the Atlantic, in the centre of which there is the still water of the *Sargasso*, or *Grassy Sea*. This area, so called from the vast accumulation of the *Sargassum bacciferum* and other floating sea-weeds, swarms with a Life, vegetable and animal, peculiarly its own, and presents one of the most remarkable features in the geography of the Atlantic.—Following the southward flow from the Azores, and the southeasterly flow from the south coast of Ireland, against which a minor current (*Rennel's*) from the Bay of Biscay impinges and recoils, there arises a new and increased stream, which holds onwards to the African continent. Of this current, the eastern portion sets in through the Strait of Gibraltar to the Mediterranean, while the western trends southward, and becomes the *North African and Guinea Current*. This stream, from 150 to 180 miles broad, closely hugs the coast, and for a long part of its course flows in contact with, but counter to, the Equatorial Current, with whose waters it is supposed ultimately to mingle in the South Atlantic.

Wherever there are return currents in any ocean—the Atlantic, Pacific, or Indian—there is formed towards the centre an area of greater quiescence, and in this area will be collected all the floating sea-weed and other drift. The sea-weed growing and matting together forms a *Sargasso Sea*, of greater or less extent and thickness, according to the stillness and temperature of the water.

140. The next and last great current of the Atlantic to which our limits will permit us to advert is the *Arctic*, Labrador, or main cold-water stream from the north. Setting strongly down the eastern coast of Greenland, it partly doubles Cape Farewell, where, augmented by the Davis Strait Current, it holds southward to Newfoundland. Arriving at Newfoundland, it sends a branch through the Strait of Belle Isle to the St Lawrence, while the main portion continues its course till it meets the Gulf Stream. Here it divides, one portion flowing southward to the Caribbean Sea, which it enters as an under-current; the other, flowing south-west, forms the United States *Counter-Current*, the line of contact between which and the heated waters of the Gulf Stream to the eastward is so abrupt, and so well marked to great depths, as we have already indicated, that it is known as the "*Cold Wall*." The main body of the waters of the Arctic Current sink downwards and continue their southward course below the waters of the Gulf Stream; and after sending off minor branches into the Caribbean Sea and the Gulf of Mexico, in the form of under-currents, they are finally lost in the general southward movement

of the deep-sea waters of the tropical regions of the Atlantic. "The Arctic Current thus replaces the warm water sent through the Gulf Stream, and modifies the climate of Central America and the Gulf of Mexico, which, but for this beautiful and benign system of aqueous circulation, would be one of the hottest and most pestilential in the world."

141. In the more limited and land-locked area of the Indian Ocean, the constant currents are few, and the periodical numerous and important. The *Equatorial* is less defined than in the Atlantic, and consists of a westward tendency of the tropical waters towards the coasts of Africa, where, divided by the large island of Madagascar, one branch sets down with considerable force, and forms the *Mozambique Current*; while another, broader but feebler, trends southward, again to be united with that from the Mozambique Channel. The combined stream, now from 90 to 100 miles broad, with a temperature 7° or 8° above that of the ocean, and with a velocity of 60 or 80 miles a-day, sets in towards the Cape of Good Hope, and constitutes the *Agulhas* or *Cape Current*. Of this current, one main branch, doubling the Cape, flows northward into the Atlantic as far as St Helena; where, meeting the Guinea Current, it is deflected westward, and merges into the Equatorial of that ocean; whereas another portion, obstructed by the Agulhas bank, is turned back, and, combining with the connecting flow from the Southern Ocean, constitutes the important *Counter-Current* of the Indian Ocean. We say "important" counter-current, for it flows along the direct route to Australia, with a velocity (after leaving the Agulhas bank) of nearly 50 miles a-day—a motion which, though gradually declining, is still sensibly felt at more than midway between the Cape and Tasmania. North of the equator, the currents and surface-drifts of the Indian Ocean are regulated by the monsoons, and vary, of course, with the seasons; while in the Red Sea, Arabian Sea, Persian Gulf, and Bay of Bengal, they set in and out with the local winds, and often change in a very complicated and capricious manner.

142. The currents of the Pacific are coextensive with its greater area, but are less decided in their courses in consequence of the numerous obstructions presented by its reefs and islands. They are altogether less known than those of the Atlantic and Indian Oceans, and their investigation is greatly complicated by the frequency of counter-currents, surface-drifts, and local gyrations. Being all but excluded from the Arctic Ocean, it is to the great interchange between the cold waters of the Antarctic and the warmer waters of the equator that we must look for the primary

impulse of its currents. Beginning with the Antarctic, to which it opens broadly, we have first the *Drift Current* of that ocean setting in towards the north-north-east, then north-east, and lastly towards the east-north-east till it nears the coast of Chili, where it divides—sending one branch south along the coast to form the *Cape Horn Current*, and another northwards to form the *Peruvian Current*, so remarkable for its cold stream along a coast of torrid temperature. This Peruvian, Chili, or “Humboldt’s Current” (as it is sometimes called, after its first investigator), has a temperature along more than 400 miles of its course 12° or 14° below that of the surrounding atmosphere, and 8° or 10° below that of the ocean through which it flows. As it holds on to the north it gradually becomes warmer and inclines to the west, till in 20° south latitude it turns fairly to the westward and merges into the great *Equatorial Current* of the Pacific. This vast current, occupying the entire torrid zone, and aided in its westerly flow by the trade-winds and the tidal wave, sweeps boldly across from South America on the one hand to the Indian Archipelago on the other. As it proceeds, it sends off a few minor streams to the north and south, which become *counter-currents*, but the main mass holds onward to the Indian Islands, where it is broken up into several sections, and becomes further complicated by the *monsoon drifts* of that region. One main portion, however, sets southward with its warm waters along the coasts of Australia, under the name of the *New South Wales Current*, and enters the Antarctic Ocean; while another, still more decided, trends northward of the Philippine Islands, and becomes the well-known *Japan Current*, or *Black Stream* of the Pacific—its clear deep-blue waters being darker than those of the Yellow Sea through which it flows. This last current, like the Gulf Stream of the Atlantic, which it greatly resembles in its course and character, carries the warm waters of the equator to the Northern Pacific; but having but a partial opening into the Arctic Sea by Behring Strait, it sweeps round the Aleutian Isles and shores of Russian America, and returns again, with diminished temperature, to the torrid zone. As it proceeds along the shores of Oregon and California it begins to bifurcate, one branch trending westward into the ocean, and another holding still southward and merging into the waters of the *Mexican Current*. This current, which flows along the coasts of Mexico and Central America, is an alternating rather than a constant one—depending on the monsoons of these coasts, and setting south-eastward during winter and north-eastward during the opposite half of the year. Besides the preceding, other minor currents have been

noticed in the Pacific, as the *Carolinian Monsoon Current*,—an alternating flow depending on the influence of the Indian and Chinese monsoons; the *Okhotsk Current*—an easterly set of the waters of that sea, arising from the south-east and easterly winds that prevail there during the summer; the *North Equatorial Counter-Current*; and *Mentor's* (after the Prussian surveying vessel of that name) or the *South Equatorial Counter-Current*. These, however, and others of less note, are but partially known; the numerous islands and reefs of the Pacific not only interrupting the regular flow of the major currents, but rendering the minor ones more complicated and less decided in their directions.

143. Such are the principal *constant* currents of the ocean—the *periodical* and *variable* being too multifarious and local for the limits of a general outline. And yet, as regards these latter, it may be observed that some, though variable in volume and velocity, are constant as to direction; and though periodical as to the season of the year, are constant as to the time and extent of their periodicity. The drift currents of the Indian Ocean which depend on the monsoons (see Winds) are periodical, and yet, one season with another, we may regard them as constant in volume and velocity. The under-currents which set in from the Indian Ocean into the Red Sea and Persian Gulf are constantly flowing, and yet they will vary in volume and velocity, being greatest from May to October, the season of greatest evaporation in these inland waters. In like manner, but to a less degree, the under-currents which set into the Baltic from the North Sea, and into the Black Sea from the Mediterranean, will vary according to the season; while a similar variation may take place in the surface and under currents which flow in and out through the Strait of Gibraltar. Wherever there are local currents depending on seasonal evaporation, the influx of flooded rivers in spring, or the melting of snow and ice, there will be seasonal variations in the volumes and velocities of these currents, and yet, in a general sense, they may be considered as a part of the constant and permanent machinery of the ocean.

144. In whatever character marine currents may appear, they are all-essential to the equilibrium and uniformity of the ocean. Excessive evaporation in the torrid zone is instantly counter-balanced by an influx from the temperate and frigid. The heated waters of the equator are modified by the colder currents from the poles; while the warmer and lighter waters of the equator flow over to temper the rigours of the polar seas. The salter and denser water of one area subsides and flows off as an under-current to some fresher region; while the fresher and lighter flows

in from above to supply the deficiency. The heavier ever descends and the lighter ascends; and thus, vertically as well as horizontally, an incessant circulatory and equalising system is established throughout the expanses of the ocean. The colder ever flowing to the warmer, and the warmer to the colder, their influence also extends to that of the lands against which they impinge, and thus additional warmth and moisture are borne to one country and refreshing coolness to another. Climate, and consequently terrestrial life, vegetable and animal, are modified by these currents; and in all likelihood they play equally important parts in the distribution and arrangement of the life of the ocean. Some coursing in shallow streams, and others pressing forward as deep and impetuous rivers, they must exercise considerable influence in transporting the sediments of the ocean—here arresting the progress of icebergs, that drop their burden of boulders and gravel on one zone, and there fostering the growth of animalcules and zoophytes (foraminifera, corals, &c.), that drop their exuviae and rear their structures in another zone equally definite and restricted. Besides these great natural functions, they often subserve the purposes of navigation and commerce; and though the steam-ship has rendered the mariner less dependent on winds and tides and currents, he still skilfully seeks to avail himself of the favouring stream of one current and to avoid the opposing influence of another.

145. "The great oceanic currents," says one of the most eloquent expounders of our science, "are among the grandest phenomena presented by the wise economy of nature. Their extent, the prodigious length of their course—in some nearly equal to the circumference of the globe—fill us with astonishment, and leave far behind everything of this description to be seen in the water-courses of the continents. Owing to these permanent streams the sea-waters mingle from pole to pole, and move with sleepless flow from the Pacific to the Indian Ocean, and from thence to the Atlantic; and this unending agitation preserves their healthfulness and purity. Like the winds, the currents tend to equalise differences, to soften extremes. The cold waters of the antarctic pole temper the scorching heats of the coast of Peru; the warm waters of the Gulf Stream lessen the severity of the climate of Norway and the British Islands. Their importance is no less in the relations and the commerce of the nations. It is the currents which, together with the winds, trace the great lines of communication upon the highways of the oceans, favouring or obstructing the intercourse of one country with another, bringing near together places apparently the most remote, separating others that

seem to touch each other. Their importance in nature and history cannot fail to impress the mind even of the most unob-servant."

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter, attention has been directed to the waves, tides, currents, and other movements to which the waters of the ocean are generally subjected. Waves are produced by the friction and impact of the winds, and occasionally by earthquake commotions. Wind-waves vary from a mere ripple of the surface to billows 10, 20, 30, and 40 feet in height, according to the power of the wind, the extent of sea, and depth of water; but earthquake-waves have been known to rise to 60 or 80 feet, and, rolling in with wall-like front and greater impetus, are far more powerful and destructive. The latter, however, are rare, and luckily confined to limited areas; while the former may be said to be universal, but varying in magnitude according to the force of the wind, and the extent, depth, and conformation of the sea in which they occur.

Tides are produced by the attraction of the moon and sun acting on the mobile waters of the ocean. In consequence of the earth's rotation there are two tides a-day; and owing to the moon's revolution, and her position as regards the sun, there are two spring-tides and two neap-tides a-month. The moon being the nearer luminary, her attraction or tide-wave compared with that of the sun is as 100 to 38; and from this cause also the difference between spring-tide and neap-tide in any locality is as 7 to 3. Had our planet been covered by a uniform sheet of water, the flow of the great tidal wave would have proceeded with unvarying regularity in time, height, and velocity all round the globe; but owing to the interruption and conformation of the continents, the varying depths of sea, and similar irregularities, it differs in different areas; and yet in each of these areas its rise and fall are as unvarying as the rotation of the earth or the revolution of her satellite.

The currents of the ocean depend partly upon the unequal temperatures and densities of its different regions—the colder and warmer, the denser and lighter, the salter and fresher, incessantly tending to interchange and equilibrium; and partly upon the movements of the atmosphere above—the trade-winds of the tropics and the constant breezes of the temperate regions forcing

the superficial waters beneath them to move in a corresponding direction, and drawing the surrounding waters into the general circulation. These currents are either constant, periodical, or variable—the constant depending on the primary and established relations of the earth ; the periodical, on monsoons, tides, and sea and land breezes, which occur in certain seas at stated seasons ; and the variable, on local winds, melting of ice, river-floods, and other similar contingencies.

To those who may wish to enter more fully into the consideration of the waves, tides, and currents of the ocean—their directions, volumes, velocities, and causes—we have again to recommend perusal of Captain Maury's 'Physical Geography of the Sea,' formerly the only popular treatise upon the subject in the English language, though many of his conclusions are now superseded. An able paper on 'Oceanic Circulation,' by Dr Carpenter, in No. 138 of the Proceedings of the Royal Society of London, may also be read with much instruction, as may also his article "Atlantic" in the recent edition of the 'Encyclopædia Britannica.' The Challenger publications should also be consulted, as well as the able memoirs of Dr Croll ; and last but not least, an excellent popular work upon the entire subject, the *Thalassa* of Dr John James Wyld.

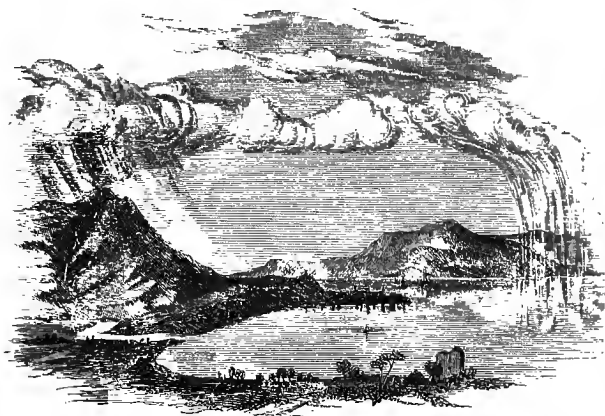
X.

THE WATER—SPRINGS, STREAMS, RIVERS, LAKES.

146. HAVING directed attention to the Water, as manifested in the larger expanses of oceans and seas, we now turn to its minor exhibitions in springs and streams, rivers and river-systems, lakes and lacustrine areas. In the former instance the waters were truly oceanic, and characterised by their *saltiness*; in the present instance they are more terrestrial, if we may so speak, and characterised, for the most part, by their *freshness*. They belong, however, to the same great aquatic system. The vapour elaborated from the ocean ascends invisibly and diffuses itself through the atmosphere, where, subjected to colder currents, it is condensed, and becomes visible in clouds, mists, and fogs. Receiving further condensation through greater cold or electrical agency, it returns again to the earth in the form of dew, rain, hail, sleet, and snow. When in the atmosphere, water belongs to the domain of Meteorology; when it returns to the earth, it comes once more within the province of the Hydrographer, who tracks it in spring, stream, and river to the ocean. The circulation of water is incessant: now in the ocean, now in the atmosphere, now in the tissues of plants and animals, now in the crust of the earth, now coursing its surface, and anon in the ocean—again to repeat the same circuit, and this without intermission while the present relations of the universe endure. Than water, there is no substance in nature more protean in form—vaporiform, liquid, solid; more ceaseless in movement—vapour, rain, spring, stream, river, wave, tide, oceanic current; or more beneficent in function—tempering the atmosphere, nourishing life, remodelling the rocky crust, and, so far as civilisation is concerned, performing some of the most important mechanical and chemical operations.

147. In general, the circulation of water is slow and gradual—so slow that the spherule of vapour now rising from the ocean may

be years, or even ages, in returning to its native source. Disseminated in the tissues of plants, or locked up in the crystallisation of minerals, its cycle seems interminably arrested; and yet we know that decay and degradation will some day or other bring about its liberation. On certain occasions, however, and in certain localities, its circulation is so rapid that you absolutely perceive the hazy vapour ascending from the sea, rolling landward in mist and cloud, coming in contact with cold mountain-peaks, condensing into rain, and falling in torrents to augment the runnels and rivulets. From runnel to stream, from stream to



Circulation of Water.

river, the mass swells, and hurries downward and onward to the great receptacle whence the light and filmy vapour originally arose, there to renew the same career, and again to perform analogous functions.

“Water,” says the eloquent author of the ‘Physical Geography of the Sea,’ “is Nature’s carrier. With its current it conveys heat away from the torrid zone, and ice from the frigid; or, bottling the caloric away in the vesicles of its vapour, it first makes it impalpable, and then conveys it by unknown paths to the most distant parts of the earth. The materials of which the coral builds the island, and the sea-conch its shell, are gathered by this restless leveller from mountains, rocks, and valleys in all latitudes. Some it washes down from the Mountains of the Moon, or out of the gold-fields of Australia, or from the mines of Potosi; others from the battle-fields of Europe, or from the marble-quar-

ries of ancient Greece and Rome. These materials, thus collected and carried over falls or down rapids, are transported from river to sea, and delivered by the obedient waters to each insect, and every plant in the ocean, at the right time and temperature, in proper form and in due quantity. Treating the rocks less gently, it grinds them into dust, or pounds them into sand, or rolls and rubs them until they are fashioned into pebbles, rubble, or boulders. The sand and shingle on the sea-shore are monuments of the abrading and triturating power of water. By water the soil has been brought down from the hills, and spread out into the valleys, plains, and fields for man's use. Saving the rocks on which the everlasting hills are established, everything on the surface of our planet seems to have been removed from its original foundation, and lodged in its present place by water. Protean in shape, benignant in office, water, whether fresh or salt, solid, fluid, or gaseous, is marvellous in its power."

Springs—their Characteristics.

148. The water that falls on the surface of the land is partly and mainly carried off in runnels, partly supplies the wants of plants and animals, and partly sinks into the soil and rocky strata. Percolating the rocks, it collects in chinks, fissures, and other cavities, or, meeting in with some impervious bed, it accumulates in the porous strata above, and there forms extensive sheets of subterranean water—some beds of sand, sandstone, chalk, and earthy limestones holding nearly their own weight of water. In virtue of the great law of gravity, water is ever tending to lower levels, and thus what gathers in the higher portions of the crust, finds its way, in process of time, through rents and crevices, and, springing forth, holds on its course to the valleys below. Where there are no impervious beds in the higher lands to intercept its downward tendency, it often percolates to vast depths, and far below the surface of the adjacent valleys; but sooner or later it is arrested by some obstructing stratum, and there, in obedience to hydrostatic pressure, it bursts forth through the nearest outlet, and rises to the surface with a force proportionate to the height and volume of the accumulated waters. In whatever manner water may accumulate within the crust, or find its way again to the surface, the outlets are known as *springs*; and these springs occur in all countries and at all levels—some issuing with force even from the bed of the ocean. It is usual to speak of them as surface springs and deep springs, as perennial, intermit-

tent, hot, cold, mineral, and the like—characteristics, the consideration of which belongs more, perhaps; to Geology than to Physical Geography.

149. It may be noticed, however, that *surface springs* are those which issue from superficial beds of sand, gravel, and the like, and being immediately dependent for their supplies on the amount of rainfall, are often very feeble or altogether dry in summer, though gushing forth copiously during winter. *Deep-seated springs*, on the other hand, uninfluenced by summer droughts or winter rains, flow steadily at all times—though, generally speaking, the great majority of springs are more or less affected by the seasons. *Perennial springs*, as the name implies, are those that flow year after year without signs of abatement. They are evidently deep-seated; and many that were celebrated by the ancients gush copiously now as they did thousands of years ago. *Intermittent*, on the other hand, are those that well forth at one period, and at another stop suddenly, and seemingly in a capricious manner. They are no doubt connected with subterranean reservoirs, whose waters alternately sink beneath and rise above their outlets; and this may be occasioned by sudden droughts and rainfalls, by the expansion and escape of steam and gases, by the ebb and flow of the tides, and other kindred causes.

150. Surface springs generally vary in temperature with the seasons; deep-seated ones, being beyond these influences, are equable at all times. It was stated in par. 18 that the earth's crust, at the depth of 80 or 90 feet, is unaffected by summer's heat or winter's cold; but that below this depth the temperature went on increasing at the rate of 1° Fahr. for every 60 feet of descent. Springs whose sources are above this invariable stratum will therefore fluctuate in temperature according to the season of the year; those that ascend from beneath it will gradually increase in heat—the deeper being the hotter. Of the latter we have instructive examples in the Artesian wells of France and other countries—those borings emitting water from 60° to 90° and upwards, and this strictly according to depth, and altogether independent of the nature of the strata through which they are carried. *Cold springs* generally flow from chilled mountain sources; *hot springs*, on the other hand, arise either from vast depths, or are situated in the neighbourhood of volcanic action. Thermal and hot springs (hot even beyond the boiling-point of water, and accompanied by violent jets of steam) occur abundantly, and on a gigantic scale, in Iceland, the Azores, Central Asia, New Zealand, California, the Andes, and other volcanic regions; they occur also in Britain, the Pyrenees, Germany,

Austria, and other countries far removed from any centre of volcanic activity. Like ordinary springs, hot springs are either perennial or intermittent—perennial, like those of southern France and the Pyrenees, that have flowed without abatement since the time of the Romans ; and intermittent, like the Geysers (“roarers”) of Iceland and New Zealand.

151. The waters that percolate the earth being of different temperatures, and often containing carbonic acid and other gases, act chemically, less or more, on the rocks through which they pass. In this way they become *mineral springs*—that is, hold in solution various mineral ingredients, which are either deposited along their courses on land, or borne onward to the ocean. Some, for example, are saline, or contain salt ; some chalybeate, or contain iron (*chalybs*, iron) ; some silicious, or contain flint (*silex*) ; some calcareous, or contain lime (*calx*) ; while others give off sulphurous vapours, or are impregnated with the salts of various minerals and metals, which confer on them very complicated chemical characteristics. Such are the sulphuretted waters of Harrogate, the brine-springs of Cheshire, the borax-springs of Tuscany, the travertine or lime-depositing waters of the Anio, the silicious hot springs of Iceland and the Azores, and thousands of others that occur in almost every country. To the same category also belong escapes of steam, hot mud, and the like, so frequent in volcanic districts ; and in the same way may be ranked discharges of gases, naphtha, petroleum, and so forth, which generally come to the surface in connection with water, and are seemingly dependent on its percolating and hydrostatic power. In familiar language the water of mineral springs is spoken of as *hard*, in contradistinction to rain and river waters, which are said to be *soft*—soap readily dissolving in and forming a lather with the latter, but curdling on and refusing to mingle with the former. The quality of mineral springs, as remedial agents, is of general importance, and has long been studied ; it is also of special value to the geologist and miner as indicating the nature of the rocks through which the waters percolate.

152. Insignificant as springs may individually appear, they perform in the aggregate most important functions in the economy of nature. If the waters, as they fall from the atmosphere, were immediately carried off by surface-runnels, the earth would at one time be flooded, and at another parched by destructive droughts. Sinking, however, into the soil, and diffused through its mass by capillary attraction, percolating the crust by capillarity and hydrostatic pressure, and accumulating in its fissures and porous strata, this water is stored up, as it were, for future

use, and given out by springs in moderate and continuous supplies. These springs are the great vivifiers of external nature, supplying one of the main wants of animal life, and clothing even the desert around them with verdure and blossom. They are the frequent fountain-heads of our streams and rivers, whose channels, but for this incessant discharge from the earth, would often be reduced to a mere succession of stagnant pools, instead of flowing, as they now do, with never-failing currents. Ever silently seeking their way down through the rocky crust, these springs dissolve some minute portion, and, bringing it to the surface, either deposit it along their runnels or carry it to the ocean, there to compensate for the abstraction of mineral ingredients by the plants and animals that inhabit its waters. Acting chemically, this internal permeation of water is evidently connected with the formation of mineral crystals and metalliferous veins, and also with that greater metamorphism of rock-masses by which strata of one nature are in process of time converted into strata of another and very different nature.

Streams—their Characteristics.

153. *Streams*, as explained in par. 43, are formed by the union of several springs, and by the union of one stream with another, till, increasing in breadth and volume, they assume the character of rivers. When mainly dependent on springs (though augmented by rainfalls), they are said to be *permanent*; but when arising solely from rainfalls, melting of snow, and the like, they are *temporary*, and often of short duration. Permanent streams are usually distinguished, according to their dimensions, as *rills*, *streamlets*, *brooks*, *rivulets*, &c. (each country, and even province of a country, having its own expressive term for such distinctions), and their currents form *ravines*, *glens*, *gorges*, *valleys*, and other descriptive excavations. Temporary streams, on the other hand, are little noticed save in regions subjected to periodical rains, their dry courses being known as *nullahs* in India, *wadies* in Arabia, *creeks* in Australia, and so on in other localities. Streams occur in all countries, but fewest and least, of course, in rainless latitudes. Their great headquarters are the slopes of mountain-chains and the outer margins of valleys exposed to the moisture-laden currents of the atmosphere, and there they impress on the country geographical features and geological relations peculiarly their own. Coursing down the mountain-sides with headlong speed, they form ravines, gorges, and waterfalls—their excavating power de-

pending primarily upon their volume and velocity ; and, secondarily, on the nature of the materials to be eroded. The aggregate amount of *débris* brought down by streams and torrents is enormous ; and one has only to cast his eye over some lofty mountain-slope to see how deeply it is scarred and seamed and furrowed by these restless and resistless agencies. In fact, the great diversity of mountain scenery depends on this erosive power of water—all the hills and highlands depending less for their present outlines on the igneous forces by which they were upheaved, than on the meteoric and aqueous agencies to which they have been subsequently subjected.

154. Streams, like springs, subserve important purposes in the economy of nature. They constitute a great network of drainage for the land—carrying off superfluous moisture, and preventing its accumulations in bogs, swamps, and morasses. They are at once the carriers and distributors of water—dispensing in measured supplies the heavy rainfalls, melting snow and ice of the highlands, to the less rainy regions of the plains below. Geologically, they are incessant workers of change,—here cutting out ravines, glens, and gorges—there filling up lakes with the eroded material ; here wearing deeper channels for the further drainage of swampy lowlands, and there assisting in that universal transport of sediments to the ocean which is destined to become the strata of future lands. Man, too, ever early locates himself on their banks, employing their perennial supplies in the wants of his home, in the irrigation of his fields, or as a cheap and effective agent in the turning of his machinery. No wonder, then, that in times more primitive and poetic than our own, every spring and stream had its presiding deity and spirit to be worshipped—the untutored mind adoring, in secondary causation, that vivifying principle which the more enlightened intellect can trace to a higher and diviner source.

Rivers—their Characteristics.

155. As streams are formed by the union of springs and minor runnels, so rivers are formed by the union of streams. In general they have their origin in some notable spring, lake, morass, or melting glacier, far up among the mountains. This infant current, augmented by the accession of other springs, becomes a main stream ; and this stream, by the influx of other *affluent* or *tributary* streams, very soon assumes the dimensions of a RIVER. A river is thus said to have its *head* or *source* in some higher

region, to flow along a certain *course*; to wear out for itself a *bed* or *channel*, whose margins form its *banks*; and ultimately to discharge its waters into some lake, sea, or estuary by a *mouth* or *mouths*. In other words, every river has a *rise*, *flow*, and *fall*, which form the essential features of its existence. Where the ground, in the ultimate part of a river course, is low and level, and the current becomes sluggish, there often accumulate shoals and *eyots* or river-islands; and not unfrequently the augmented waters discharge themselves by several branches and form a *delta* (par. 89), as in the Nile, Niger, Indus, Ganges, &c.; and such deltas may be either marine, lacustrine, or fluviate, according as the rivers flow into the sea, a lake, or another larger river. Where the tides and river-currents contend and neutralise each other's force, there frequently accumulates across the entrance a spit of sand or gravel, known as a *bar*; and these bars are serious impediments to the navigation of some of the finest rivers. As all rivers flow from higher to lower levels, the terms *up* and *down* have reference to this natural condition; and as a spectator descends with the current, the *right bank* lies on his right hand, and the *left bank* on his left. When he ascends, however, this order is reversed—the right bank being then on his left hand, and the left bank on his right.

156. The whole extent of country drained by a river and its tributaries is spoken of as the *basin* of that river (basin of the Thames, basin of the Tay, &c.); and this naturally, from the hollow or valley-shaped aspect which such districts usually assume. As streams unite to form rivers, so several river-basins may descend towards the larger depression of some inland sea; and thus geographers speak of the "basin of the Baltic," the "basin of the Mediterranean," and, carrying the idea still further, even of the "basin of the Atlantic." As the great oceans form the ultimate receptacles for all the rivers (with one or two exceptions), the river-basins that descend to any ocean constitute what is termed the *river-system* of that ocean; and thus we have the Arctic System, the Atlantic System, the Pacific System, and the System of the Indian Ocean—together with the Aralo-Caspian System, and the minor basins of Utah, the Mexican table-land and the plateau of Bolivia, whose streams are strictly continental, and confined to these areas. There are thus two kinds of river-systems; the *oceanic* discharging themselves into the ocean—and the *continental*, whose waters never reach the ocean, but are held in equilibrium by evaporation and absorption. The line or ridge that separates one basin or system from another basin or system is termed the *watershed* of these basins (or *watersched*, if we affect

a German derivation)—all the springs and streamlets “shedding or parting off,” as if from the ridge of a house, to their respective areas. Though hills and mountains generally form the boundaries between river-basins, it does not follow that watersheds should always consist of elevated ground—a few feet of fall being sufficient to determine the current in either direction. The low ridge that thus separates the streams of different basins is spoken of as a *portage* (Fr.), from the fact that goods and boats are frequently carried across from one stream to another; and thus, it may be, completing the passage by water from one side of a continent to another.

157. Such are the usual *terms* employed by geographers in treating of rivers; the *characteristics* of the rivers themselves—that is, their rise, course, length, volume, depth, velocity, capability of navigation, and the like—require more detailed consideration. As to their *rise*, it has been already stated that it generally takes place in some upland spring, lake, or morass, and not unfrequently in the melting terminus of some descending glacier. Many of these springs, especially those issuing from chasms and caverns in limestone districts, are often of considerable magnitude, being, in fact, full-flowing streams when they make their appearance at the surface. Mountain lakes, being the recipients of springs and other runnels, become in like manner copious sources—the streams that flow from them being already rivers in miniature. The same may be said of morasses and high swampy tracts, which, being saturated with springs and rainfall, discharge at once regular and continuous streams. Where a mountain lake receives a number of small feeders, it is justly regarded as the “source” of the river to which it gives rise; but where one of the feeders assumes decided importance, that feeder is looked upon as the infant river, and must be traced to a higher and farther fountain-head among the mountains. Glaciers and melting snows are also occasional sources, as in the Alps, Himalayas, and other snow-clad mountains; and, where merely accessories, become important regulators of supply in the regions where they occur—their waters flowing freest when the summer’s heat has most diminished the lowland streams.

158. Whatever their origin—and it must be confessed that the exact sources of many of our larger rivers are unexplored and undetermined—their *courses* are primarily directed by the general slopes of the continents. In the Old World, the great slopes being north and south, the principal rivers flow in these directions, just as in the New World their courses are easterly and westerly, in obedience to the relief of that continent. But while this is true,

and necessarily so, as regards the main slopes, it should be borne in mind that there are many causes tending to modify the courses and directions of rivers. Among these, for example, may be noted the strike of the secondary hills and spurs, which are usually at right angles to the main chains; the occurrence of lines of fracture in the crust; the passage from one formation to another whose strata lie in a different direction; and the alternation of softer and harder beds—the current readily excavating its channel in the line of the former, but obstructed and turned aside in another direction by the latter. All these, and many other circumstances of a geological nature, concur in giving to streams and rivers very irregular courses—winding and bending, turning and returning, but still guided in the main by the primary slope of the region.

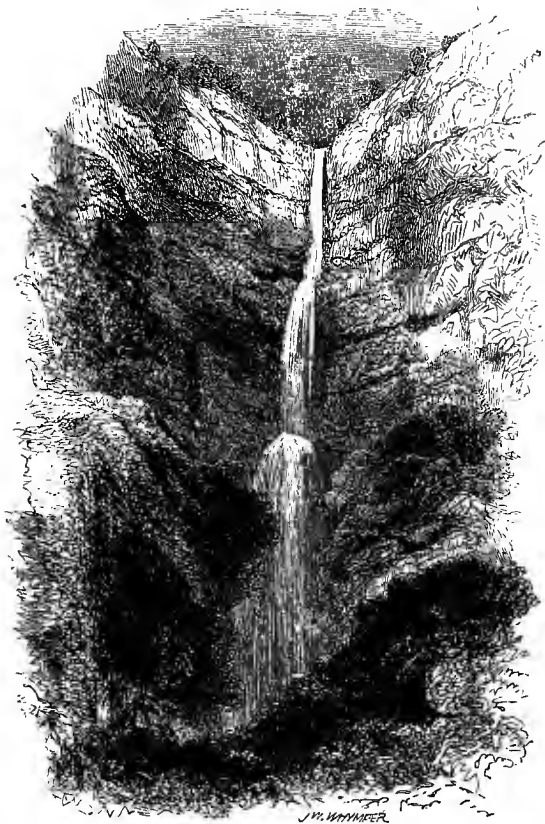
159. As to the *length* of their courses, that will depend primarily upon the extent of the region through which they flow—the larger area giving scope to the longest river; and, secondarily, upon the bendings and windings to which they may be subjected. The direct distance between the source and outlet of a river may not exceed two hundred miles, and yet its absolute course, through all its doublings and windings—its *development*, as it is termed—may amount to a thousand. This absolute length gives no true idea, however, of the importance of a river, either in nature or to navigation—its value mainly depending on the permanence of its volume, its depth, and velocity. The *lengths of rivers*, so often tabulated in geographical works, are, for the most part, little better than guess-work, and, even were they more accurate as to figures, they are still of little use—the real natural and economical value of a river resulting, as we have already said, from the permanence of its volume, the slowness of its current, its depth, nature of channel, accessible entrance, and influx and efflux of the tides.

160. The *volume*, size, or magnitude of a river—that is, the quantity of water which its channel contains—depends on many collateral circumstances, but chiefly on the extent of country drained by its affluents. There may occasionally be some peculiarity of basin as regards rainfall, melting of snow, and the like; but, generally speaking, the greater the area over which the tributaries ramify, the greater the quantity of water brought to the main trunk or channel. In temperate latitudes this volume is somewhat lessened in summer and increased in winter; but, on the whole, the supply is pretty equable and permanent. Sudden excesses, arising from heavy rainfalls, rapid melting of snow in spring, and the like, are merely temporary, producing what are termed *floods*, *freshets*, and *debacles*. In tropical countries, on the other hand, where the rains fall and the snows melt only at stated

seasons, these floods assume the character of regular and *periodical inundations*. And where the rain falls in the low countries at one period, and the far-off mountain snows melt at another, there may be two such inundations occurring with wonderful regularity both in time and amount of overflow. Again, where the sources of a river lie near the equator and its outlet in the temperate zone (as in the case of the Nile), a considerable time must elapse between the equatorial rainfall and the deltic inundation; and the length of this lapse will depend partly on the windings of the river, and partly on the slope and freedom of the channel. In the preceding instances, whether subjected to irregular floods or periodical inundations, the river itself is always more or less *permanent*; but in some regions, as Australia and South Africa, many of their so-called rivers are merely *temporary*, being roaring impetuous torrents during the rains, and a succession of stagnant pools and dry shingly reaches during the season of drought.

161. The *velocity* of a river depends mainly on the slope or declivity down which it flows, partly on the nature of its channel, according as this may be straight or winding, deep and narrow, or wide and obstructed by rocks and shoals, and partly also on the amount or volume of its current. As all rivers descend from higher to lower regions, and many of them from very elevated sources, they may be said to have an upper, middle, and lower course; the *upper* being characterised by rapidity of stream through gorge and glen and waterfall—the *middle* by less velocity through rapids and cataracts—and the *lower* by a quiet steady flow through level and alluvial plains. Rapids, cataracts, and waterfalls, though detrimental to the navigation of rivers, are objects often of great interest and marvel—some of them, like Niagara, Yosemite, Victoria on the Zambesi, and Kaieteur on the Potaro in British Guiana, being amongst the most stupendous of natural phenomena. Other things being equal, the deeper the river, the more rapid the current—the greatest velocity being in the centre of the stream, and a little below the surface, where there is least retardation from friction on the sides and bottom of the channel. “The speed, however,” it has been well remarked, “does not depend entirely either upon slope or depth, but also upon the height of the source of the river, and the pressure of the body of water in the upper part of its course; consequently, under the same circumstances, large rivers run faster than small, but in each individual stream the velocity is perpetually varying with the form of the banks, the winding of the course, and the changes in the width of the channel.”

Cataracts and waterfalls are usually produced by the river cutting through harder and softer rocks—the softer yielding to the current, and the harder resisting, so that the stream has to



Tseen-chang-yan Waterfall, China.

leap as it were over these harder rocks into the chasm or channel below. Dykes of porphyry, felstone, basalt, and the like, or beds of conglomerate and siliceous limestone, are generally the rocks over which the current has to fall, or through which it has to force its way. Among the more stupendous waterfalls in the

world may be noted that in the *Yosemite* valley, California, where a stream as large as the Thames at Richmond is said to make a single leap of not less than 2100 feet ; *Niagara*, between Lakes Erie and Ontario, where the river, 3225 feet wide, is divided in two by Goat Island, and falls on one side sheer 162 feet, and on the other 149 feet ; *Victoria Falls*, on the Zambesi, where the river, 1000 feet wide, is suddenly swallowed up in a narrow perpendicular cleft, 100 feet deep ; *Kaieteur*, on the Potaro, in British Guiana, where the stream, 134 yards wide, has a total fall of 822 feet—741 of which is a sheer perpendicular descent into a vast seething caldron below ; *Schaffhausen*, on the Rhine, 72 feet ; those of the *Glommen* in Norway ; those of the *Clyde* in Scotland ; and some lofty threads of water (1000, 1400, and 2000 feet) which descend from the Alps and Pyrenees.

162. The velocity of rivers is an all-important consideration in their geographical, geological, and commercial relations. The more rapid their currents, the less the irrigating effect, and the greater the geological effect on the countries through which they flow ; and in proportion as their velocity increases, so their fitness for the purposes of navigation is diminished. Formerly a descent of more than 1 foot in 200 was considered unnavigable ; and though the power of steam has enabled man to contend with higher velocities, it is still the velocity of current more than the depth of water that renders a river unavailable as a means of internal communication. Geologically, the cutting as well as transporting power of rivers is greatly aided by the rapidity of their currents ; hence the effect of mountain torrents compared with the quiet sluggish flow of the lowland river. It has been calculated, for example, that a velocity of 3 inches per second will tear up fine clay, that 6 inches will lift fine sand, 8 inches sand as coarse as linseed, and 12 inches fine gravel ; while it requires a velocity of 24 inches per second to roll along rounded pebbles an inch in diameter, and 36 inches per second to sweep angular stones of the size of a hen's egg. During periodical rains and land-floods the currents of rivers often greatly exceed this velocity ; hence the tearing up of old deposits of gravel, the sweeping away of bridges, and the transport of blocks many tons in weight—an operation greatly facilitated by the circumstance that stones of ordinary specific gravity (from 2.5 to 2.8) lose more than a third of their weight when immersed in water. It must ever be remembered, however, that the eroding power of a river depends very much on the nature of the rocks through which it flows : one traversing a country consisting of the softer rocks—sandstones, clays, and shales—rapidly deepening and widening its

channel ; while another, passing over the harder rocks—granites and greenstones—effects little or no change for ages.

163. The *depth* of rivers is as various as the circumstances under which they occur, though, generally speaking, the greater the volume of water, the deeper the channel of excavation. In their upper and middle courses, the stream, being for the most part through steep rocky excavations, is of no great depth ; but in the lower and slower portion the waters accumulate and deepen as they proceed. The *outlet*, or *embouchure* (Fr.), as it is frequently termed, depends altogether upon the conformation of the country. Some rivers discharge themselves at once and by a single mouth into the ocean ; others into an estuary, and are consequently affected for a certain length by the flux and reflux of the tides ; while others, again, creep sluggishly along, branching and bifurcating through their swampy deltas, till they find their way into the sea by several main mouths. Seeing that the conditions of rivers are so exceedingly varied, their *facilities for navigation* will depend in each case on the nature of the outlet as accessible from sea and free from bars and banks, on depth and volume of water, and on the velocity of the current. Length of course and volume of current may be obstructed by rocks and shoals in the bed of the river ; depth of channel may be rendered unavailable by shallow bars and shifting sandbanks at its mouth.

Oceanic River-Systems—their Characteristics.

164. It will be seen from what has been stated respecting the characteristics of rivers, that each has its own individuality, and that this individuality depends in the main on the geographical position, extent, and superficial configuration of its basin. To give an account of these basins would be to describe in detail the rivers that traverse the surface of the globe—a subject which extends beyond our limits, and belongs more especially to hydrography and general geography. All that our outline will permit is the arrangement of the basins into SYSTEMS, and a notice of some of the more remarkable rivers that belong to each system. As all the affluent streams of a river belong to one basin, so all the river-basins that descend to the same ocean-basin—whether directly, as the Niger to the Atlantic, or intermediately through some inland sea, as the Nile to the Atlantic through the Mediterranean—belong to the same river-system. In this way we have four great *oceanic river-systems*—the Arctic, Atlantic, Pacific, and Indian ; and one or two minor *continental* ones, as the Aralo-

Caspian, the Utah, the Mexican, and the Bolivian. To the main characteristics of these respective systems, and the leading rivers that compose them, the attention of the student is now directed.

165. The *Arctic System*, as the name implies, embraces those rivers which, obeying the northern slope of the Old and New World continents, discharge themselves into the basin of the Arctic Sea. Lying for the most part within the limit of constantly-frozen ground, and flowing through notably level plains, there is a degree of sameness in the conditions of these waters which renders the Arctic more homogeneous in its character than any other river-system. For convenience, however, it may be divided into three sections—Asiatic, European, and American—according as the rivers belong to these respective areas.

166. The Asiatic section comprehends the great Siberian rivers—the Kolyma, Indigirka, Lena, Olenek, Yenisei, and Obi, which, rising in the Altai, Yablonoi, and Stanovoi Mountains, receive numerous tributaries in the upper and middle stages of their course, wind slowly through the plains, and ultimately discharge themselves by wide estuarial mouths into the Arctic Sea. The largest of these are the Lena, Yenisei, and Obi, which, had they discharged themselves into temperate or tropical seas, would have taken rank with the noblest rivers on the globe. As it is, they are little known, and of little geographical importance : and here the student has an instructive example of how much relative position has to do with the physical and vital features either of land or of water. The Lena, which rises in the mountains north of Lake Baikal, has a development or winding course of 2400 miles, receives several important tributaries (Vitim, Olekma, and Aldan), and is computed to drain an area of 594,000 square miles. It is a deep sluggish stream in the lower part of its course, and finds its way into the sea between high banks of frozen mud and sand, in which are embedded the remains of mammoth, rhinoceros, and other huge mammals, which in former ages (pre-historical), and under different geographical conditions, inhabited the plains of northern Asia. The Yenisei is still larger, having a development of 2800 miles, and a basin of not less than 784,000 square miles. It receives several large affluents—the Great and Little Kem, the Angara from Lake Baikal, and the Upper and Lower Tongouska, most of which, in their upper and middle stages, are impetuous torrents, interrupted by rapids and cataracts. The Obi, or Irtysh-Obi, as it may be termed, from the equal importance of its two main branches, is the most notable of these rivers, having a development by either branch of 2400 miles, and a conjoint basin embracing nearly one-third of the

entire area of Siberia. It rises in the Lake of Toleskoi (Lake of Gold) in Great Tartary, and after leaving the mountain region its current is said to be scarcely perceptible—having a fall of only 400 feet or thereby in a distance of 1200 miles! As already mentioned, the main affluent of the Obi is the Irtysh, and the Irtysh receives in turn the streams of the Tobol and Ishim. One leading characteristic of all the Siberian rivers is, that though rapid and sufficiently diversified in the upper stages of their courses, they become sluggish and monotonous on entering the low boggy plains. Frozen, like the ocean into which they enter, for many months of the year, they are unfit for navigation; while, on the melting of the snows in their upper and more southerly sources, the swollen floods, finding an insufficient outlet by the level, ice-locked, and more northerly mouths, overspread the country in lakes and morasses, which render its surface still more dreary and inhospitable. It is only during a brief summer of two or three months that their embouchures are free and open, and then they are in high current, undermining their frozen banks, and capriciously shifting their channels.

167. The European section of the Arctic river-system embraces the Petchora, which falls directly into the ocean, and the Mezen, Dwina, and Onega, which enter it indirectly through the White Sea. With the exception of the Dwina, on which Archangel is situated, and which drains an area of 106,000 square miles, none of these rivers are of much importance, being usually ice-locked from September to June, and otherwise flowing through a flat and uninviting region. This flatness, however, permits of an extended canal-system; and it is thus that the White Sea and Baltic are connected, through these northern rivers and the Volga, with the Black Sea and Caspian, just as they will eventually be by the more rapid and effective system of railway. As in Siberia, so in this river-region of Russia, there is much bog and marsh, rendering it the most inhospitable portion of the empire.

168. The American section comprises those streams and rivers which, obeying the northern slope of that continent, find their way through a labyrinth of lakes and swamps, and ultimately fall into the Arctic Sea. The more noticeable of these are the Great Fish, the Coppermine, the Mackenzie, and the Colville. Comparatively little is known of the sources and ramifications of these rivers, of which the Mackenzie is the largest and most important. This great river, which drains an area of 441,000 square miles, is formed by the union of several streams that rise in the eastern slopes of the Rocky Mountains. The most important of these are the Athabasca and Peace Rivers, which, after passing through Lake

Athabasca, unite to form the Slave River; and this, after entering the Slave Lake, reissues as the Mackenzie. Like the rivers of Siberia, those of Arctic North America flow through low, frozen, and inhospitable swamps, and enter the sea by wide mouths; but, unlike those of Siberia, they are connected with a labyrinth of lakes, a feature peculiarly characteristic of the northern section of the American continent.

169. The *Atlantic System*, as the name implies, embraces all those rivers that find their way directly or intermediately into the great basin of the Atlantic from the slopes of the adjacent continents. It necessarily arranges itself into four sections—the European, African, North American, and South American, according as the rivers descend from either of these continents. In the European section we have certain rivers that flow into the Atlantic directly, and others that enter it indirectly through the Baltic and Mediterranean. The chief of those flowing into it directly are the Elbe, Weser, and Rhine from the western slopes of the Germanic plain; the Seine, Loire, and Garonne from France; and the Douro, Tagus, Guadiana, and Guadalquivir from the Spanish peninsula. The Rhine—the “beautiful Rhine” of the Germans—springs from Alpine glaciers at an elevation of 7650 feet, descends rapidly to Lake Constance (1250 feet), thence through the Falls of Laufen or Schaffhausen to Basel (800 feet), and thence with a navigable course to the North Sea, which it enters by the largest of European deltas. The Rhine has thus a well-marked upper and lower course, a development of 700 miles, and a drainage of 65,000 square miles; the Loire an absolute course of 520 miles, and a drainage of 33,000 square miles; while the Tagus, the third in importance, has a length of 400 miles, and a drainage of 21,000 square miles. The principal streams that discharge themselves through the intermediate basin of the Baltic are the Neva, Niemen, Vistula, and Oder—all more or less obeying a north-westerly slope, and, like their recipient, ice-locked for a considerable portion of the year. Of these the Vistula (whose windings are said to be nearly equal to nine-tenths of its direct course from source to mouth) has the greatest development and drainage—its length being 520 miles, and its basin 56,000 square miles.

170. The waters that fall from the European side into the basin of the Mediterranean are—the Ebro and Rhone into the main sea; the Po into the Gulf of Venice; and the Danube, Dnieper, Dniester, and Don into the Euxine Sea. The Rhone rises among the Alps at an elevation of 5500 feet, and, having an actual course of only 550 miles, is necessarily one of the most rapid rivers in Europe. It has a drainage of 23,000 square miles,

discharges itself by two main mouths, and, when in high flood, projects its current with such force that its fresh waters can be skimmed from the surface several miles out at sea. The waters that enter the Black Sea branch of the Mediterranean basin obey the great southern and south-eastern slope of the European continent. Of these the Don, Dnieper, and Dniester have comparatively gentle currents, and all in their lower courses flow through flat, swampy plains, which, during a large portion of the year, are little better than quagmires and morasses. The Danube, the most important of the suite, rises in the Black Forest at an elevation of 2850 feet, has a winding course of 1496 miles, and an area of 234,080 square miles. Originating in the union of several mountain-streams, it is first known as the Donau or Danube in the Duchy of Baden, from which it runs through an Alpine country to Ulm, and thence to Passau it traverses the plain of Bavaria. From Passau to Vienna it runs through a second hilly region, and the remainder of its course is generally through a flat country, except within the rocky defile of the "Iron Gate," till its embouchure by three main mouths into the Euxine Sea. The Danube and its navigable tributaries—the Theiss, Drave, and Save—form important channels of internal communication for eastern Europe—an importance that has been greatly enhanced by the adoption of steamers fitted to the peculiarities of their currents.

171. Such are the principal rivers of Europe that fall directly or indirectly into the basin of the Atlantic. Lying in the temperate zone, and having their sources at no great distance from the ocean, their volumes are wonderfully regular and persistent, being merely liable to occasional floodings from excess of rainfall, or from sudden meltings of the snow in early spring. The extent and configuration of the continent prevent the formation of large and long rivers; but as the rapids and waterfalls are confined to their upper stages, the lower portions of their courses are in most instances easy of access and more or less navigable. Whether viewed as channels of drainage and irrigation, or as means of internal communication, these rivers constitute an essential feature in the physical geography of Europe. Flowing from the central region in every direction, they equalise the water-supply more than in any other continent, confer greater beauty and amenity on its surface, and afford at once a perennial supply and an available mode of intercommunication to its busy populations.

172. The African section of the Atlantic system embraces all those rivers which flow from the western and northern slopes of

that continent—the former discharging themselves directly into the ocean, the latter indirectly through the basin of the Mediterranean. Of those entering directly into the Atlantic, the Senegal, Gambia, Niger, Congo, Coanza, and Orange are the more important, though some of these are but very partially known in their upper courses. The Senegal and Gambia, which rise in the Kong Mountains, and have courses from 600 to 850 miles in length, form the conjoint basins of Senegambia, and are navigable to some extent. The Niger, the noblest of these western rivers, is supposed to have its sources in the northern slopes of the Kong Mountains, and, after a circuitous course of more than 1500 miles, during which it receives the Chadda and other large tributaries, enters, by several navigable mouths, the Gulf of Guinea. The Niger (Joliba or Quorra) drains an immense but unknown extent of tropical Africa; has a navigable middle course of many hundred miles, varying from 1 to 6 miles in width, and running at the rate of 5 and 8 miles an hour; and possesses a low, pestilential delta of 14,000 square miles, alternately choked with the rankest jungle-growth and overspread by inundation, which attains its height about the middle of August—overtopping the mangroves, and depositing a thick coating of mud on the swamps and banks of the delta. The Gaboon and Ogowai are so far navigable, but are interrupted by rapids and cataracts, and remain unknown as to their tributaries and courses in the interior. The Congo and Coanza, also frequently interrupted by rapids and waterfalls, are comparatively unknown. The former, as has been shown by Stanley, is one of the noblest rivers on the globe, but rendered unfit for continuous navigation by these obstructions. Known in its middle course as the Livingstone, it receives many important tributaries, is of varied width, and originally issues from Lake Tanganyika, which, with many others (Bangweolo, Nyassa, &c.), occupies the central table-land south of the equator. The course of the Congo, though traversed by Stanley, still requires further exploration, especially its tributaries, which seem to flow through regions of unequalled luxuriance and fertility. The Orange or Gariep is unnavigable, being alternately a large impetuous torrent during the rains, and a shallow shingly stream during the season of drought.

173. The most important, and indeed the only African river that discharges itself into the Mediterranean, is the Nile—the most classical, and in many respects the most remarkable, river in the world. Flowing from the equatorial lake, Victoria N'yanza (3300 feet above the sea-level), as the Bahr-el-Abiad, or White Nile, it receives, after a considerable course, the Bahr-el-Azrek, or

Blue Nile, from the Galla country, and after a further tract is augmented by the Atbara from Abyssinia—the conjoint stream flowing downward through Dongola, Nubia, and Egypt (a distance of 1200 miles), without receiving any additional accession of waters. The total length from Lake Victoria is about 2300 miles, and its supposed drainage-basin is not less than 1,000,000 square miles. Little is yet known with certainty of the feeders of Victoria and other adjacent lakes, partly explored by Speke and Baker, though the general opinion is that all of them derive their head-waters from the labyrinth of mountain heights which ranges westward from Kilimandjaro through equatorial Africa. The upper course of the White Nile is described by Captain Speke as flowing through a beautiful and fertile country: its middle course through Nubia is marked by a succession of low rapids or “cata-racts,” nine or ten in number; and its lower course having a fall of only two inches a-mile, the current flows gently through the plain of Egypt, till its final discharge into the Mediterranean by the two main mouths which form its delta. This delta commences 90 miles from the sea, and has a coast-line of 187 miles between its main mouths, the Rosetta and Damietta. In the plain of Egypt, which is from 2 to 18 miles in width, the current of the Nile, when not in flood, is about $2\frac{1}{2}$ miles an hour; but in its deltic branches the flow is almost imperceptible. The most remarkable feature in the Nile is the regularity of its annual inundation, which arises, in all likelihood, from rainfalls dependent on the south-east trade-winds of the Indian Ocean, and on the melting of snows among the equatorial ranges near its sources. In its upper branches (those of the Blue Nile in particular) the river begins to rise in April, but at Cairo the flood is not perceptible till towards the summer solstice. It then continues to rise for nearly a hundred days, and remains at its greatest height till the middle of October, when it begins to subside, and reaches its lowest point in April and May. So far as we have evidence, this inundation has remained unchanged for the last 4000 years. Its height in Upper Egypt is from 30 to 35 feet, at Cairo from 20 to 24, and in the northern part of the delta, where it spreads out over a wider area, it seldom exceeds 4 or 5 feet. The fine black slime or mud deposited by this inundation has been the unfailing source of wealth and fertility to Egypt; and from its accumulation, in like manner, has arisen the formation and increase of the delta or Nilotic plain. According to Sir Samuel Baker, the greater portion of the sediment is brought down by the Blue Nile and its tributaries from the highlands of Abyssinia—the character of the rocks, the amount of rainfall,

and the impetuosity of the streams being highly favourable to rapid disintegration and erosion.

174. The rivers of South America constitute by far the most unique and gigantic section of the Atlantic system. Indeed, all the rivers of that continent obey its great eastern slope towards the Atlantic—the streams that flow down the abrupt and rainless counterslope towards the Pacific being mere runnels fed by the melting snows of the Andes. In this case we have at once area for development, supply from heavy rainfalls engendered by the moisture-laden winds of the Atlantic, as well as from melting snows and perennial springs, and breadth of volume arising from the flatness of the surface over which these rivers flow. Beginning at the south, the rivers of Patagonia are of little importance, being described as “of small magnitude, with few or no affluents, and making straight across the dry shingly terraces of that sterile region.” North of this the great river-system commences, embracing the basins of the Plata, the San Francisco, the Parana-hyba, the Tocantins, the Amazon, Orinoco, and Magdalena.

175. The Rio de la Plata, whose drainage is estimated at 886,000 square miles, receives its affluents from very distant and different regions—the Salado, Vermejo, and Pilcomayo from the deserts and salinas of the Lower Andes—the Paraguay and Parana, two noble rivers, from the wooded slopes and verdant plains of the central regions—and the Uruguay from the low sierras and valleys of southern Brazil. Some of these affluents, like the Paraguay and Parana, are navigable for hundreds of miles inland, and, on the whole, have deep and accessible channels, but are subject to periodical and destructive inundations. Their united waters meet in the estuary of the Plata—a fresh-water sea, 180 miles long, and 120 broad at its entrance; but shallow and loaded with mud, whose discoloration is perceptible far out the Atlantic. The San Francisco, having a length of 1400 miles, and an estimated drainage of 187,000 square miles; the Parana-hyba, having a drainage of 115,000 square miles; and the Tocantins, or Para, of 284,000 square miles,—are strictly Brazilian rivers, rising among, and flowing between, the sierras of that country. Little is known of their sources, but they descend with considerable currents, till they enter the lowlands that fringe the Atlantic, from which they are navigable for long distances inland.

176. The Amazon, by far the largest river in the world—having a length of 3500 miles from its remotest feeder (the Apurimac) in the Andes to its union with the ocean, and an estimated drainage of 1,512,000 square miles—is that which gives life and character to the lowlands of tropical America. Entering the ocean by an

estuary 200 miles long and 130 broad, its freshening influence is felt several hundred miles out at sea ; while, on the other hand, the tidal rise is perceptible at the distance of 576 miles from the embouchure. The main stream, though much impeded by mud-banks and islands, is navigable for 2000 miles inland, and will, one day or other, become the highway of commerce and civilisation to the fertile and exuberant region through which it flows. Its principal affluents on the right are the Xingu, Tapajos, Madeira, Purus, and Ucayali, which flow from the sierras of Brazil and the central region ; and on the left the Rio Negro, the Japura, and Putumayo, which descend from the mountains of Parimé and the northern Andes. Many of these tributaries are largely navigable, and, though treated as mere feeders of the Amazon, would be esteemed important rivers in the geography of other countries. The head-waters of the Amazon drain the entire circle of the middle Andes, almost connecting its stream by a low portage with the Paraguay on the south, and actually uniting it by the Casiquiare with the channel of the Orinoco on the north. Like other tropical rivers, the Amazon is subject to periodical inundation—its waters beginning to rise in December, being at their greatest height in March, and lowest in July and August. When in flood, its waters overspread an immense extent of country, which thus becomes alternately a fresh-water sea, and *selvas* teeming with the rankest tropical vegetation.

177. The Orinoco—the last of South American rivers to which our space will permit us to advert—has a basin of nearly 300,000 square miles, and a navigable course at all seasons of more than 1000 miles. Rising in the mountains of Parimé, it takes a circuitous course northwards and then eastwards, receiving on the one hand several important tributaries from the Andes, and on the other a number of smaller streams from the ranges of the Parimé. Increased by these affluents—the Guaviere, Meta, and Apure, on the left, and the Paraqua and Caroni on the right—it ultimately finds its way by a perfect labyrinth of mouths into the basin of the Atlantic, whose tides flow upwards into its main channel for more than 250 miles. Its annual floods take place with great regularity—commencing about the end of March, and decreasing by the end of August. During high flood, thousands of square miles of the low flat basin are inundated to a depth of 30 feet—these flats, alternately flooded and covered with long rank grass, constituting the celebrated *Ulanos* of the Orinoco.

178. The river-systems of North America are governed by the disposition of the Rocky Mountains much in the same way as those of South America are governed by the Andes. The counter-

slope of the Rocky Mountains, being less abrupt than that of the Andes, gives development to two or three streams of some importance on the Pacific side, but in the main the great river-basins are directed towards the Atlantic. The central plain that stretches from the Gulf of Mexico to the Arctic Sea being divided by a low watershed of 1300 to 1500 feet, a few rivers, as the Mackenzie and Coppermine, trend northward to the Arctic basin ; but all the larger and more important lie south of this watershed, and belong to the Atlantic system. Of these the Rio del Norte and the Mississippi fall into the Gulf of Mexico ; the St Lawrence directly into the Atlantic ; and the Saskatchewan and Churchill into Hudson Bay. The Rio del Norte, which rises among the sierras of New Mexico, has its upper course through a desert region, in which it receives few affluents ; but as it descends into the lower grounds it gains considerable accessions, and becomes a natural boundary between the United States and New Mexico. Its drainage area is estimated at 180,000 square miles.

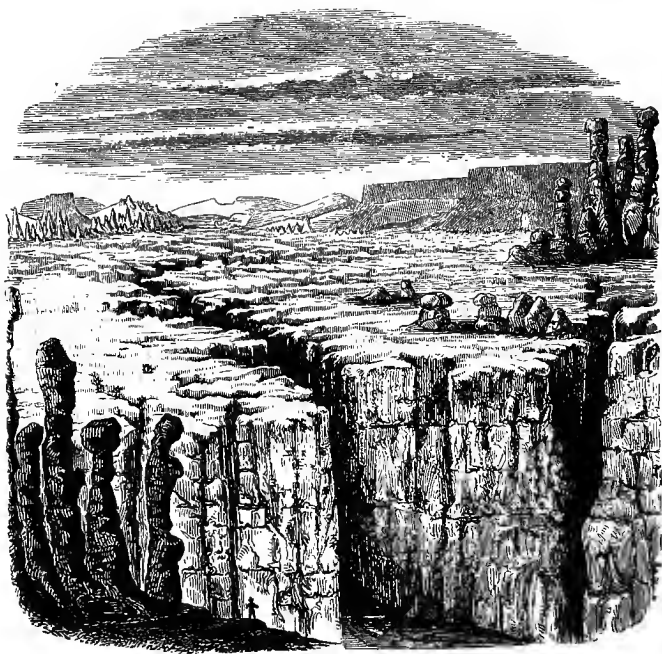
179. The Mississippi ("father of waters") is by far the largest of North American rivers. Rising in the small lake of Itasca, on the verge of the middle table-land, at an elevation of 1500 or 1600 feet, it runs southward through the great central plain, receiving numerous accessions from either side, and, after a winding course of 3160 miles, falls through a swampy delta into the Gulf of Mexico. Its main tributaries on the right or Rocky Mountain side, in which they take their rise, are the Missouri—a river even longer, larger, and having more affluents, than the Mississippi itself—the Arkansas, having also many affluents, and the Red River ; while on the left its chief tributary is the Ohio, with its numerous feeders from the western slopes of the Alleghanies. Between the Rocky Mountains on the west, and the Appalachians on the east, lies, therefore, the great conjoint basin of the Missouri, Mississippi, and Ohio, having an area of more than 1,000,000 square miles (1,210,000) ; containing every description of soil and scenery—prairie, barren, and woodland ; watered by innumerable streams and several navigable rivers ; and possessing every variety of climate, from the coldly-temperate highlands of Nebraska to the sub-tropical warmth of the Gulf of Mexico. The Mississippi, we have said, has a winding course of 3160 miles, but if the Missouri be taken as the main stream, its length is 4260 miles ; while that of the Arkansas is 2000 miles, and the Ohio more than 1000 miles. The breadth of the Missouri and Mississippi at their confluence is about half a mile, and the main stream downwards is very little more. Though gentle, the current is by no means sluggish ; and thus, during floods, from the melting of

the snow in the higher latitudes, the rivers sweep downwards immense quantities of mud, driftwood, and other debris. The Missouri is said to be navigable "from the Great Falls in the Rocky Mountains to the sea, a distance of 4000 miles ; the Mississippi, from those of St Anthony, 2240 ; while the Ohio, being connected by a system of canals with Lake Erie, and thence to Lake Ontario, carries out a water-communication between the Gulfs of Mexico and St Lawrence." The delta of the Mississippi, which projects itself forward into the Gulf of Mexico, is a low and unhealthy region, nearly 14,000 square miles in area, and full of lagoons, creeks, and pestilential marshes.

180. The St Lawrence, which forms the great water highway to Canada, takes its rise, under the name of the St Louis, far west in the central lake-region of North America. After uniting the Lakes Superior, Huron, Erie, and Ontario, it issues from the last by the name of the Iroquois, and, alternately contracting and expanding into lake-like reaches, it is known as the St Lawrence at Montreal, from whence it flows to Quebec, and thence by its long estuary into the Atlantic. Its drainage basin is estimated at 297,000 square miles, of which 94,000 or more is covered by fresh-water lakes. Its estuary is 350 miles long, and 80 broad at its mouth, but, from its northward trend, is frozen and ice-locked during the winter. The Saskatchewan and Churchill take their rise, in like manner, among the labyrinth of lakes that characterises the extreme northern plain of America, and, after flowing from lake to lake with irregular and tortuous courses, find their way to the North Atlantic through Hudson Bay. The basin of the Saskatchewan is estimated at 300,000 square miles, and that of the Churchill at 73,000, but a large portion of both is occupied by lakes and frozen morasses.

181. Encompassed as the *Pacific* is by the continent of America on the one hand, and by that of Asia on the other, its *river-system* is altogether peculiar, and disproportionate to the encircling areas. On the American side, from Tierra del Fuego to the Gulf of California, there is not a single stream of importance. From that point northward to Behring Strait the chief river of note is the Colorado, which rises among the sierras of New Mexico, and drains with its tributaries an arid and rocky area of 170,000 square miles, cutting its way through *cañons* or gorges, often of extreme depth, and ultimately falling into the Gulf of California. The chief cañon of the Colorado has for the greater part of 200 miles of its length nearly vertical walls from 2000 to 6000 feet in height. Next comes the Columbia, with its main tributary the Lewis, descending with impetuous current over waterfalls and cataracts

from the Rocky Mountains, traversing the Oregon territory, and draining an area computed at 194,000 square miles; the Fraser, an equally rapid stream, rising among the ranges of the Rocky Mountains, and watering the wild but picturesque country of British Columbia. Finally, we have the Yukon, a large but little known river, draining the inhospitable uplands of Alaska, and, after a course of more than 1500 miles (600 of which are navigable for flat-bottomed boats), falls, by many mouths, into the Behring Sea. Abutting as the Andes and mountains of Mexico do upon the very shores of the Pacific, there is no space for the development of rivers; and it is only where the Rocky Mountains bend inland, and are flanked by minor hill-ranges, that the Colorado, Columbia, and Fraser make their appearance.



Cañon of Colorado.

182. On the Asiatic side of the Pacific the case is altogether different, the mountains from which the rivers descend being not

only far inland, and thus affording ample area for development, but being, moreover, the recipients of abundant rain and snow fall. We have thus, descending the eastern slopes of Asia, the Amoor in Chinese Tartary; the Hoang-ho (Yellow River), Yang-tse-kiang (Great River), and Tche-kiang in China, and the Menam and Mekong in Cochin-China—all first-class rivers—besides a vast number of affluents and minor streams that add to the fertility and importance of that region. The Amoor (Tunguse, “Great Water” of the Manchooks, Sagalhien, or “Black Water”) rises high in the Daurian Mountains, receives several large tributaries in its descent, and, after a course of 2400 miles, enters as a navigable river into the land-locked Gulf of Tartary, which opens on the one hand into the Sea of Okhotsk, and on the other into the Sea of Japan. It drains an area of nearly 583,000 square miles; and, from its navigable capabilities, safety of entrance, and relative position to Japan and Russian Siberia, is likely to become of considerable commercial importance. The great rivers of China—the Hoang-ho and Yang-tse-kiang—take their rise among the Kihan-shan and Kuen-lun Mountains, that buttress the plateau of Tartary, and after making their descent between the minor ranges of the Yun-ling and Pe-ling, wind with slow and steady flow through the plain of China into the Yellow Sea. The course of the Hoang-ho, or Yellow River (so called from the colour of its waters) is estimated at 2300 linear, and its basin at 537,000 square miles; while the course of the Yang-tse-kiang is 2900 linear, and its drainage area not less than 548,000 square miles. Though their main mouths are wide apart, yet they may be said to fall into the same delta—their broad navigable streams being united throughout their lower courses by innumerable canals and natural channels. Indeed the whole country, from the southernmost branch of the Yang-tse, north to the Pei-ho or White-River, which enters the Pe-che-le Gulf, is one alluvial flat, intersected by channels, canals, and embankments, and liable to be flooded and broken in upon by shiftings of the river-courses, and other similar changes. One of the most notable of these shiftings took place in the Hoang-ho, about 1854, when, instead of falling due east into the Yellow Sea, it took a northerly bend, and now enters the south-western portion of the Gulf of Pe-che-le—a deflection caused by the Taeping rebels stopping the dredging in the lower artificial course, and cutting the embankments at Kae-fung. The burden of sediment which these rivers carry down to the shallow basin of the Yellow Sea is immense; and their deltas are rapidly growing into dry land—so rapidly, that within the memory of some Chinese traders, what were mere mud-shoals are now fertile

rice-lands. Though frequently shifting their channels, and cumbered by shoals and mud-banks, they are navigable by vessels of considerable burden for 600 or 800 miles, and by smaller craft to perhaps double that extent. The Mekong ("mother of waters") is a large but little-known river, rising in the mountains of Eastern Assam, flowing with a long course between the mountain-ranges of Cochin-China, draining, along with the Menam, an estimated area of 216,000 square miles, and falling into the Gulf of Siam or Cambodia by a many-mouthed delta. The Menam begins to rise in June, is in full inundation in August, and on its subsidence deposits a thick layer of fertilising mud, which, under a tropical sun, soon gives rise to a luxuriant and tangling wilderness of vegetation.

183. *The river-system of the Indian Ocean* has three separate and independent sections—the Asiatic, the Australasian, and the African, according as the rivers flow from either of these regions. The Asiatic embraces the Martaban, Sitang, and Irawady in Burmah; the Brahmapootra, Ganges, and Indus in India; and the Tigris and Euphrates in Persia and Asia Minor. The Martaban, Sitang, Irawady, and other rivers of Further India, occupying the narrow valleys which lie between the parallel hill-ranges of that region, flow southward in long and comparatively straight courses. Very little is known of their sources or affluents; but the Irawady, which enters the Gulf of Martaban by a broad and many-branching delta, is navigable for 500 or 600 miles, and, though encumbered in its lower course by mud-banks and islands, is a channel of vast importance to the Burmese empire. During the season of inundation it spreads to a breadth of 3 or 4 miles, runs at the rate of 4 or 5 miles an hour, and is heavily laden with sedimentary debris. There is, indeed, a great similarity among all the rivers of the Indo-Chinese peninsula, whether flowing like the Menam and Mekong into the Pacific, or like the Martaban, Sitang, and Irawady into the Indian Ocean. Rising among the Kakhyeen Hills and ranges of Western China, their upper courses are generally through gorges and over rapids; their middle courses are long and straight, and flow with considerable current through a country rich in tropical vegetation; while in their lower courses they spread out and enter the sea by several mouths through low and gradually increasing deltas. The delta of the Irawady, for instance, which forms a sort of equilateral triangle with a side of about 70 miles, is cut up in its lower part into an infinity of islands by a vast labyrinth of creeks and channels. Within the full tidal influence, according to Captain Yule (*Geog. Jour.*, vol. xxvii.), these islands are lined with mangrove

thicket, and further up with forest of a nobler kind, or more commonly with a fringe of gigantic grasses. A very small portion of these *sunderbunds* is under cultivation, and even far from sea vast tracts of fertile soil remain in a state of nature or abandonment.

184. The Ganges, which rises at an elevation of 13,000 or 14,000 feet among the glaciers of the Himalayas, descends rapidly to the plain of India, and there flowing with gentle current, it receives numerous affluents from the southern slopes of its parent mountains on the one hand, and from the northern slopes of the Vindhya high grounds on the other, till it ultimately falls through a many-branching delta into the Bay of Bengal. The Brahmapootra ("offspring of Brahma") is formed by the union of two main streams. The more northerly of these, the Dzangho-chur, has its origin in the northern slopes of the Himalayas, and flows eastward till its union with the Brahmapootra proper, which, descending from the distant recesses of the Tibetan mountains, runs southward towards Assam. After their junction, the united waters, under the name of the Brahmapootra, cut transversely the eastern Himalayas, and then, flowing south and westward with a volume considerably exceeding that of the Ganges, enter the delta of that river about 40 miles above the sea. The conjoint area, drained by these rivers and their affluents (several of which are larger than the Rhine), is estimated at 432,000 square miles, and their respective lengths at 1980 miles. Like other tropical rivers, the Ganges and Brahmapootra are subject to annual inundations—the floods commencing in April, attaining their maximum about the middle of August, and continuing till October. They begin first to swell from the melting of the snows among the mountains, but before this influence has reached the low grounds these are widely under water from the periodical rainfalls. The quantity of water arising from these two causes and brought down by the Ganges and Brahmapootra is enormous, overspreading the plains for hundreds of square miles, and freshening more or less the whole upper area of the Bay of Bengal. The amount of sediment brought down by these rivers when in flood is also immense; and the whole delta, 200 miles in length and 180 broad at its base, with all its channels, creeks, lagoons, and mud-islands (*sunderbunds*), is clearly the offspring of this debris. Though liable to sudden shiftings during inundations, several of the branches of the Gangetic delta are navigable at all seasons for vessels of large draught; while the main stream can be ascended by smaller craft to the foot of the Himalayas. Though possessing a large volume, the Brahmapootra, from the rapidity of its current and the ob-

stacles in its channel, is of less importance as a means of internal communication.

185. The Indus, the third great river of India, takes its rise in the highlands of Tibet, and after a precipitous course through the western Himalayas, descends into the plains, where it is augmented by the streams of the well-known Punjab, or Five Rivers. These affluents, like the main stream, are the offspring of the Himalayas, and drain a large expanse of upland as well as fertile lowland. After their union near the southern extremity of the Suleiman hills, the Indus receives no more tributaries of any note, but flows with gentle current through a somewhat arid country for nearly 300 miles, and then forks into a delta 80 miles long by more than 100 broad at its base, discharging itself by many mouths, only three or four of which are navigable. The annual floods commence with the melting of the Himalayan snows in April, attain their greatest height in July, and terminate in September. The winding course of the river is nearly 2000 miles, and its estimated drainage 312,000 square miles; but owing to the shallow and shifting nature of its mouths, it is navigable only by vessels of comparatively small burden. Lying open to the great tidal wave of the Indian Ocean, it has, like the Ganges, a rapid and dangerous *bore*, which ascends the main channels to a distance of 60 or 70 miles.

186. The only rivers of importance that enter the Indian Ocean from western Asia are the Euphrates and Tigris—celebrated in ancient history, and still flowing through a fine but neglected country. Their conjoint drainage-basin is roughly estimated at 200,000 square miles, and both have well-marked upper, middle, and lower courses. The Euphrates and its affluents rise in the table-land of Armenia, and after a long and tortuous course the main river descends in rapids through the Taurus chain into the plain of Mesopotamia. The Tigris and its tributaries rise in a similar manner to the east, in the highlands of Kurdistan, pierce also in its middle course the Taurus chain, and thence descend by slow and winding channels through the Mesopotamian plain. Both rivers flow parallel for a long distance through this beautiful lowland, and ultimately join at Korna, a distance of 150 miles from the head of the Persian Gulf, which receives their united waters. The development of the Euphrates, the greater river, is estimated at 1600 or 1800 miles, fully one-third of which flows through a plain naturally one of the most fertile and exuberant. "The banks of the Tigris and Euphrates, once the seat of an extensive population, and of art, civilisation, and industry (Babylon, Nineveh, &c.), are now, however, nearly deserted, covered

with brushwood and grass, dependent on the rivers alone for that luxuriant vegetation which, under an admirable system of irrigation, formerly covered them." The floods of the rivers are said to be very regular in their rise and fall—beginning in March, and attaining their greatest height in June.

187. Australia, owing to its geological conformation, is singularly destitute of rivers—those descending the eastern counter-slope of its hills into the Pacific being mere streams, while those flowing from their western slopes seem to lose themselves in the great central plains. The Murray, with a winding course of 1300 miles, and its tributaries the Darling, Lachlan, and Murrumbidgee, are the only known rivers of note; and these, though roaring torrents during the rains, and rising in the course of two or three days to 20 or 30 feet, are often reduced to a mere chain of ponds and creeks in the dry season.

Of the African rivers that enter the Indian Ocean, geography knows too little as yet to offer anything like reliable description. The Zambesi is the largest and most important, apparently draining an immense extent of inland country, 600,000 square miles in area, which spreads out in plain-like expanses, reticulated by streams that flow during the periodical rains, but are desiccated and partially obliterated during the season of drought. On the whole, recent investigation seems to point to the interior of Central Africa as a plateau-shaped plain, deriving its main water-supply from rains, which form, for the most part, only temporary streams and lakes—the surplus being carried off by evaporation rather than by a regular system of stream and river drainage.

188. Such is a brief outline of the chief river-systems of the world—the Arctic, Atlantic, Pacific, and Indian. Though the basins of which they are composed have their own individual characteristics, there is still a great similarity, and necessarily so, among the various members of a system. Thus the rivers of the Arctic system run more or less meridionally, flow from *warmer* to *colder* latitudes, and all their embouchures are for a large portion of the year ice-locked and impervious to navigation. By the melting of the snows in their upper courses they are flooded before the thaw has reached their lower waters, and thus the plains through which they pass are largely occupied by lakes and morasses. The rivers that descend the southern slopes of Asia, Europe, and North America, flow also in meridional courses, but pass, on the contrary, from *colder* to *warmer* latitudes, and consequently their embouchures are open at all seasons. Those of them that belong to the Atlantic system derive their floods chiefly from the melting

of the snows along their upper courses ; while the inundations of those belonging to the Indian system depend partly on the melting of the snows and partly on the periodical rainfalls in their lower courses. With the exception of the Rio del Norte and the Mississippi on the one hand, and the rivers that enter the Mediterranean on the other, all the basins of the Atlantic system, whether from the American, European, or African continents, run in latitudinal courses ; and thus, from their sources to their embouchures, each passes along the same climatological zone. These and other great geographical conditions must at once present themselves to the mind of the inquiring student, and produce the conviction that the idea of *river-systems* has something more to recommend it than the mere convenience of artificial arrangement.

Continental River-Systems—Inland Basins.

189. Besides the oceanic systems there are what have been termed *Continental Systems*—a few inland basins cut off from all connection with the ocean, and having the equilibrium of their waters maintained by evaporation and absorption. The chief of these, as already mentioned, are the Aralo-Caspian basin in Asia ; the Utah and Mexican in North America ; the basin of the Andes plateau in South America ; and in all likelihood, when better known, some similar depressions in Australia and Central Africa. On referring to the map, it will be seen that a number of the streams of central Asia—the Asiatic plateau—run inland to lakes, or lose themselves in the sand and shingle of the desert. This is the “Basin of Continental Streams” in Asia, and includes the Lob, Balkash, Helmund, and other lake-hollows, with their tributary streams ; the Aral, with its main feeders the Syr and Amoo ; and the Caspian, with its rivers the Oural and Volga. Of these the most important is the Volga, which rises on the Valdai slopes at an elevation of 633 feet, and, after a long and winding course of 2400 miles, during which it receives many important tributaries (the Kama, Viatka, &c.), falls by two main mouths into the Caspian Sea, which is 82 feet below the level of the Euxine. The Volga is the largest river in Europe, has a fall of only 633 feet during a course of 2400 miles, drains an estimated area of 397,640 square miles, and constitutes the great internal water-way of Russia. The seas and lakes of this basin, as indeed of all other continental basins, having no escape for their waters save by evaporation, must necessarily be more or less salt ; and hence the saline peculiarities of the Caspian, Aral, Balkash, Dead Sea, Lake

of Utah, and others occurring in these so-called "basins of continental streams." Basins of this kind necessarily occur in rainless flats and plateaux; for were the amount of rainfall exceeding the evaporation, the sheets of water would accumulate till they overflowed their margins, and found an outlet, like other lakes, towards the nearest oceanic area.

ABSTRACT OF RIVER-SYSTEMS.

ARCTIC.

	<i>Drainage Basin.</i>	<i>Length.</i>	<i>Development.</i>
	Sq. m.	Geog. m.	Geog. m.
Obi, ...	924,800	1276	2400
Yenisei, ...	784,530	1228	2800
Lena, ...	594,400	1280	2400
Kolyma, ...	107,200	440	800
Indigirka, ...	86,400	600	1000
Olenek or Olensk, ...	76,800	500	910
Anadir, ...	63,400	300	550
Dwina, ...	106,400	380	864
Petchora, ...	48,800	360	600
Saskatchewan, ...	360,000	924	1664
Mackenzie, ...	441,600	964	1154
Churchill, ...	73,600	668	850
Albany, ...	52,800	380	560

ATLANTIC.

Neva, ...	67,200	315	440
Rhine, ...	65,280	360	700
Vistula, ...	56,640	280	520
Elbe, ...	41,860	344	684
Oder, ...	39,000	280	480
Loire, ...	33,000	320	520
Duna, ...	33,440	280	560
Douro, ...	29,250	260	440
Garonne, ...	24,450	200	320
Seine, ...	22,620	220	340
Tagus, ...	21,960	360	400
Guadiana, ...	19,360	240	420
Guadalquivir, ...	15,000	180	260
Niger, ...	440,000	1200	1500
Congo, ...	520,000	1100	1400
Nile, ...	520,200	1820	2300
Rhone, ...	23,950	232	552
Po, ...	23,160	248	560
Ebro, ...	25,100	268	420

	<i>Drainage Basin.</i> Sq. m.	<i>Length.</i> Geog. m.	<i>Development.</i> Geog. m.
Danube, ...	234,080	880	1496
Dnieper, ...	169,680	548	1080
Don, ...	168,420	408	960
Dniester, ...	23,050	360	440
Great Lakes and St Lawrence, .	297,600	860	1800
Connecticut, ...	8,000	231	270
Delaware, ...	8,700	180	265
Orinoco, ...	292,000	370	1350
Essequibo, ...	61,650	350	420
Amazon, ...	1,512,000	1548	3500
Tocantins, ...	284,480	990	1120
Paranahyba, ...	115,200	560	744
S. Francisco, ...	187,200	870	1400
La Plata, ...	886,400	1028	1920
Mississippi-Missouri, ...	1,210,000	2100	4260
Rio del Norte, ...	180,000	1220	1840
Magdalena, ...	72,000	560	830

PACIFIC.

Amoor, ...	582,880	1200	2400
Yang-tse-kiang, ...	548,800	1550	2900
Hoang-ho, ...	537,400	1150	2300
Tche-kiang, ...	99,200	480	960
Columbia, ...	194,400	576	1360
Colorado, ...	170,000	512	800

INDIAN OCEAN.

Ganges and Brahmapootra, . . .	432,480	821	1980
Indus, ...	312,000	900	1900
Menam, ...	216,000	600	1499
Euphrates, ...	195,680	600	1600
Godavery, ...	92,800	540	750
Kistna, ...	81,000	440	690
Irawady, ...	331,000	1100	2200
Zambesi, ...	600,000	1800	1500

CONTINENTAL SYSTEMS.

Volga, ...	397,640	900	2400
Oural, ...	53,200	550	700
Konr, ...	64,600	300	640
Sir, ...	237,000	600	1200
Amoo, ...	193,000	800	1400
Loh Lake, ...	177,000	620	1000

Lakes and Lacustrine Areas.

190. *Lake* is the general term for any considerable body of standing water surrounded by land, and not directly connected with the sea or any of its branches. Lakes are thus strictly terrestrial expanses, and belong to the land as much as the streams

and rivers that channel its surface. Wherever there is a depression of that surface beneath the surrounding country or the bed of the nearest river, there water will accumulate (unless carried off by evaporation) till it rises above the lowest part of the enclosing margin and flows off by some river-channel. In this way we may have sheets of all sizes, from the merest pools to lakes occupying many thousands of square miles. Lakes generally consist of *fresh water*; but some, like the Caspian and Aral, having no river of discharge, are *salt*, while others, having only partial outlets, are *brackish*. They occur in all regions, but most abundantly on mountain table-lands and plateaux, and on the lower reaches of great plains. Lakes owe their origin to a variety of causes. Some, like the lakes of Central Africa, seem to lie in broad depressions of the earth's crust. Others, like those of many mountain regions, lie apparently in the deeper wrinkles formed during the compression and partial elevation of the rocks of the district. Others, like the *lagoons* of gently sloping shores, are merely shallow bays cut off from the sea-waters by piled-up bars and sandbanks. A few, like the lakes of Central Italy, lie in the craters of extinct volcanoes. Wherever there is a want of declivity, or any obstruction to the natural flow of the surface-waters, there lakes will accumulate, and this in proportion to the extent of country, the magnitude of the obstruction, and the amount of rain and snow fall. In consequence of less evaporation, they occur also more abundantly in high than in low latitudes; and hence their frequency and magnitude in the northern regions of America, Europe, and Asia, as compared with other areas. It has been further noticed, that lakes, at least the smaller of them, occur more numerous in tracts that have been subjected to ice-action during the "glacial period" of geology—some being dammed up in glens by old moraines, and others scooped out as rock-basins by glaciers.

Speaking of the connection between lakes and glacial action, Sir Charles Lyell remarks "that they are common in countries where glaciation occurs, and comparatively rare in tropical and sub-tropical regions. When travelling over some of the lower lands in Sweden, far from mountains, as well as over the coast region of Maine in the United States, and other districts in North America, I was much struck with the innumerable ponds and small lakes, of which counterparts are described as equally characteristic in Finland, Canada, and the Hudson Bay territories. I have never seen any similar form of the surface south of latitude 40° N. in the western, and 50° N. in the eastern hemisphere. The relation of a certain number of these sheets of water to the

glacial period is obvious enough, for not a few of them are dammed up by barriers of unstratified drift, such as may have constituted the lateral and terminal moraines of glaciers, or may have been thrown down from melting icebergs when the country was still under water. By similar reasoning other geologists, as Professor Ramsay, account for the occurrence of mountain-lakes in rock-basins—these basins having been hewn and chiselled out, as it were, by the long erosion of glacier action.

191. It is usual to arrange lakes into *four* kinds: 1. Those that have neither outlet nor inlet—subterranean springs and rain supplying the water, and evaporation carrying off the excess. These are generally of small dimensions—lowland pools, mountain-tarns, and not unfrequently the craters of extinct volcanoes. 2. Those which have an outlet, but receive no running water, being fed by springs rising from their bottoms and rocky margins. Lakes of this class are also small, and for the most part situated in upland districts. 3. Those which, like the Caspian and Aral, receive streams of running water, but have no visible outlet—the balance of level being maintained by evaporation. Such lakes are more or less impregnated with saline matter; and this saltiness must be still on the increase. 4. Those that both receive and discharge streams of running water, and which form alike the most numerous and most extensive in both hemispheres.

192. To whatever class they belong, lakes form essential elements of diversity in the landscape, and perform important functions in the economy of nature. Exposing considerable surfaces to evaporation, they serve to temper the aridity of their respective districts, at the same time that they act as so many reservoirs in which the superabundant supplies of winter are stored up for the increased requirements of summer. In many instances they act as checks to the too rapid discharge of rivers—retaining for perennial supply what would otherwise be run off in a few days, and restraining, moreover, the destructive flood which is brought to rest in their placid areas. Occurring so frequently in the course of rivers, they act as settling-pools for the debris and sediment of their waters—the streams they discharge being pure and pellucid, whilst those they receive may be turbid and laden with impurities. In this way they get gradually silted up, and form rich alluvial tracts, the while that their outlet-currents are deepening their channels and forming the means of a more efficient drainage. In this way lakes become important agents in the surface-modification of the land; and one has only to cast his eye over the fertile dales and vales of long-established regions to perceive how

much of these areas was at one time a mere succession of lakes and morasses. Biologically, too, these fresh-water sheets become the habitats of a peculiar flora and fauna—thus extending the range of Life, and affording conditions of existence that no other habitat could supply.

193. In Europe there are two main lake regions—a highland and a lowland; the former embracing the picturesque lakes of Britain, Switzerland, and Italy; the latter the numerous sheets that stud the Baltic provinces of Russia, Prussia, and Sweden. The highland lakes generally occupy the deep narrow troughs of mountain-glens, and from their situation and adjuncts are celebrated for their scenery; the lowland, on the other hand, spread over areas little depressed beneath the surrounding country, and are for the most part tame and unattractive. The waters of highland or Alpine lakes are usually retained by rocky barriers, through which the outflowing stream is gradually deepening its channel, and thus their dimensions become less and less as the drainage outlet becomes deeper. On the contrary, the drainage of lowland sheets is often slow and sluggish; hence a large portion of their areas is little else than morass, which the accumulation of aquatic vegetation and sedimentary matter is year after year converting into alluvial land.

194. With two or three exceptions (Platten See, Neusiedler See, &c.), the European lakes, strictly so called, consist of fresh water; they have all, or nearly all, streams of ingress and egress; vary in size from a few hundred square yards to several thousand square miles; and all rise slightly with the rains of winter and fall with the droughts of summer. The more notable in the northern lowland regions are Lakes Ladoga 6330 square miles, Onega 3280, Saima 2000, Peipus 1250, and Enara 1200 square miles, in Russia; and Lakes Wener 2130, Wetter 840, and Maelar 760 square miles, in Sweden—the latter being only three or four feet above the level of the Baltic. The larger Alpine lakes are on the Swiss side; Geneva or Lemman, 240 square miles, at an elevation of 1230 feet; Constance, or the Bodensee, 228 square miles, at an altitude of 1250 feet; Neuchâtel, 114 square miles, and 1440 feet high; Lucerne, 98 square miles, and 1430 feet high; and Zurich, 74 square miles, at an elevation of 1330 feet: while on the Italian side there are Garda 182, Maggiore 150, and Como 66 square miles, at elevations respectively of 326, 680, and 685 feet. In the British Isles, Loughs Neagh, Corrib, Erne, and Loch Lomond, respectively 150, 63, 56, and 45 square miles in area, and 48, 31, 130, and 22 feet in elevation, are the largest, though others of smaller dimensions (Killarney, Westmoreland,

and the Trossachs) are better known for their picturesque scenery and associations.

195. In Asia, the lakes occupy three main and distinctive regions—the mountains and plateaux of the central highlands, the alluvial lowlands of China and Siberia, and the depressed areas of the Aralo-Caspian and Dead Sea. Unlike those of Europe, many of the Asiatic lakes are salt or brackish, and this peculiarity belongs more especially to those having no river of outlet. Respecting these salt or brackish sheets, accounts differ considerably as to the amount of saline matter held in solution in their waters—a difference that may arise either from taking the specimens at different places (some being drinkable at one end, and at the other very brackish), at different seasons of the year, or from errors in analysis. Whatever the source of error, there can be no doubt that where new saline supplies are continually carried in by rivers and springs, and none carried off by running water, the percentage must be gradually on the increase. Of the *saline* lakes, the more important and better known are the Caspian (slightly fresher than the ocean), 83 feet beneath the level of the Black Sea, having an area of 130,000 square miles and an extreme depth of 960 feet; the Aral, 36 feet above sea-level, and having an area of 26,000 square miles; Balkash or Tengiz, having an area of 7000 square miles; Urumiah (25 per cent of salts), 1800; Van, 1600; Zurrah, 1600; Tongri-nor (*nor*, lake), 1800; Koko-nor, 1500, at an elevation of 10,500 feet, salt and undrinkable, and of an exquisite blue colour; Lob, 1300; and the Dead Sea, 360 square miles, with a depression of not less than 1298 feet beneath the level of the Mediterranean, an extreme depth of 1308 feet, and containing from 24 to 26 per cent of saline ingredients. Of the *fresh-water* sheets the largest is Baikal (the “Holy Sea” of the Russians), in Siberian Tartary, with an area of 14,800 square miles, and at an altitude of 1363 feet; and Tong-Ting, Poo-Yang, and Tai-Hou in China, having respectively areas of 2000, 800, and 700 square miles, and all valuable aids to the internal communication, commerce, and agriculture of that peculiar country. Besides these may also be noted Zai-zan in Mongolia, 1000 square miles; Booka-nor in Tibet, 1000; Erivan in Armenia, 500; and Tiberias in Syria, 76 square miles, at a depression of 328 feet beneath the Mediterranean.

The Dead Sea, as may be gathered from Robinson’s ‘Physical Geography of the Holy land,’ occupies the lowest or deepest part of the Ghôr, the deep valley or *fissure* which extends from Mount Hermon to the Red Sea. This great chasm in part of its length (180 miles) is depressed to an extent which has been variously

estimated at from 1298 to 1312 feet beneath the level of the Mediterranean. The Dead Sea lies about midway of this whole line of depression, of which it occupies somewhat less than one-fourth part. The greatest length of the sea is about 40 miles, and its breadth from 9 to $9\frac{3}{4}$ miles—limits which somewhat vary with the dry and wet seasons of the year. Its greatest depths are from 1080 to 1308 feet, but towards the south where it shoals it is nowhere over 10 or 12 feet. It is surrounded on all sides, save the extreme south, by precipitous cliffs from 1000 to 1500 feet in height—the mountains sometimes jutting down into the water, and only here and there leaving a narrow strip of pebbly and shingly shore. The water of the Dead Sea has a slightly greenish hue, and objects seen through it appear as if seen through oil. It is most intensely and intolerably salt—far more so than sea-water, and leaves behind a nauseous bitter taste, not unlike Glauber's salts. It contains from 24 to 26 per cent of saline ingredients—chiefly chlorides of sodium, magnesium, calcium, and potassium; and its specific gravity, according as the water is taken nearer or further from the influx of the Jordan, varies from 1.15 to 1.23. This great specific gravity gives to its waters much buoyancy, and persons unable to swim elsewhere can here swim without difficulty, or can lie upon the water, or sit and stand in it without effort. Its saltiness is utterly inimical to aquatic life; it contains no fish or shell-fish, and those swept down by the floods of the Jordan expire the moment they breathe its saline and bitter waters.

196. In Africa there are several lakes less or more known to geographers; but while the internal configuration of that continent remains undetermined, it is impossible to arrange them into anything like systems or areas. Between the Atlas range and the Sahara, and fed by streams from the former, there exists a series of minor lakes, of which the largest (Londeah, &c.) lies in Tunis; in the hilly region of Nigritia the existence of sheets of considerable magnitude (Tchad, Dibbie, Fittie, &c.) has been so far determined; in the equatorial region, Victoria, 21,500 square miles, and 3300 feet above the level of the sea; Albert, of unknown area, and 2720 feet above the sea; and several other reservoirs of the Nile. In the southern table-land occur many fluctuating sheets: Nyassa, 9000 square miles in area, and 1500 feet above the level of the sea; Tanganyika, 9240 square miles, 2756 feet above the sea, and of unknown depth; Bangweolo, 150 miles long, &c., &c. The last two, from the western flow of their effluent rivers, as has been proved by Stanley, form the sources of the Livingstone or Congo. Indeed, as shown by

Livingstone, Stanley, Cameron, and other explorers, the heart of Africa, instead of being a thirsty and arid table-land, is a well-watered plain, or series of plains, often densely wooded, and abounding in products (mineral, vegetable, and animal) unrivalled by any other tropical region. Among the longer known lakes may be mentioned Dembea or Tzana in Abyssinia, at an elevation of 6270 feet, and embracing an area of 1400 square miles; the deltic areas of Menzaleh and Mareotis in Egypt; and the salt-water lake of Assal in Abyssinia, extending to 30 square miles, and lying in a depression 570 feet beneath the level of the Red Sea.

With regard to Australia, we know that certain areas covered with water during the rains are but marshes or mud-pools during the season of drought, and that along many portions of the sandy coasts there exist saline and brackish lagoons; but we are yet too slenderly acquainted with the interior to speak with certainty as to the existence of *lakes*, in the true sense of the term, either fresh-water or saline. So far as has been gathered from the reports of exploring parties, the chances are against the existence of perennial lakes, though numerous creeks and temporary pools, such as Lake Eyre, Lake Gardner, and Lake Torrens, are scattered at occasional intervals over the continent.

197. In South America there are comparatively few lakes, and these, for reference' sake, may be arranged into three distinctive regions—namely, the mountain-glens and depressions of the higher Andes; the low plains that border the eastern flanks of the Andes; and the still lower river-plains that trend toward the Atlantic. Of the Andean lakes the most remarkable is Titicaca, situated at an elevation of 12,847 feet, embracing an area of 3800 square miles, and stamping peculiar features on the scenery, life, and civilisation of the surrounding district. It is fed by several streams from the Andes, but discharges itself by a single outlet, the Desaguadero, which after a short course disappears, partly by evaporation and partly by absorption into the sandy and arid soil through which it flows. Of the lakes that skirt the Andes on the east, many of them are of temporary nature, being extensive sheets during the rains, but mere marshes and salt pools (*salinas*) during the period of drought. In the lower plains of the Plata, Amazon, and Orinoco there exist many creeks, lagoons, and stagnant areas that appear in the dry season as lakes, and during the rains as one vast area of inundation.

198. In North America the lakes may be said to affect only two main districts—a highland and a lowland; the former the troughs and depressions of the Rocky Mountains from Panama

on the south to Columbia on the north, and the latter the northern section of the great central plain from the southern boundaries of Canada to the Arctic Ocean. In the former area the more important sheets are Nicaragua, 3500 square miles, at an elevation of 128 feet; Maragua, 450 square miles; and Yojoa, 150 square miles, in Central America; Chapala in Mexico, 1000 square miles; and in the United States, Utah, 150 square miles; and the Great Salt Lake, 1800 square miles, at an elevation of 4200 feet. Of the lowland section the more important and extensive are the great "fresh-water seas" that form the lacustrine chain of the St Lawrence. These are Superior, with an area of 32,000 square miles, an altitude of 628 feet, and a depth of 900 feet; Michigan, 24,000 square miles, altitude 574 feet, and depth 1000 feet; Huron, 20,000 square miles, altitude 574, and depth 1000 feet; Erie, 9600 square miles, altitude 565, and depth 84; and Ontario, 6300 square miles, altitude 232, and depth 500 feet. Besides these, there is the immense lacustrine network of the extreme north, forming with that of Canada a lake-region unsurpassed by any other on the globe. Of the larger of these boreal, shallow, marshy, and long-frozen lakes we may enumerate Great Bear, 19,000 square miles; Great Slave, 12,000; Winnipeg, 9000; Winnipegosis, 3000; Athabasca, 3000; Deer, 2400; Manitoba, 2100; Wollaston, 1900; and Lake of the Woods, 1200 square miles,—the presence of which tends to render the region more rigorous in climate, and all but impassable even to the hunter and trapper.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter attention has been directed to what may be termed the *terrestrial* waters of the globe—that is, to the springs, streams, rivers, and lakes that occur on the land in contradistinction to the great united mass which constitutes the Ocean. Though separable in this way, it is still the same vast volume of waters we have to deal with, its appearance on the land being only local and temporary. The vapour exhaled from the ocean is conveyed to the land, where, condensed into rains and snows, it falls and forms springs and streams, and these by their union give birth to rivers and lakes. But the stream and river are ever hurrying to the ocean again—again to be evaporated as *fresh water*, again to fall as rain and snow, and again to course the dry land, and to carry with them a portion of those ingredients which, accumulating within certain limits, constitute the peculiar *saltiness* of the ocean. The rain and snow that percolate

the rocky crust reappear at the surface as *springs*, which, according to their situation, may be superficial or deep-seated; according to their supply, temporary, intermittent, or perennial; according to their temperature, cold or thermal; and according to the rocky material through which they pass, either pure or mineral—that is, impregnated less or more with saline, calcareous, siliceous, chalybeate, and other mineral and metallic substances. By their union, springs and surface rivulets form *streams*, and these streams occurring most abundantly in hilly regions, unite one with another as they descend to the plains, and there ultimately form *rivers*, whose continually augmented volumes constitute one of the most important features in the hydrography of the globe.

The highest or farthest-off spring to which we can trace a river constitutes its *source* or *rise*; and from this source, through all its windings till it finally falls into the sea by one or by many mouths, lies its *course*. It is usual to divide river-courses into upper, middle, and lower stages—the upper being characterised by ravines and waterfalls, the middle by rapids and cataracts, and the lower by a broad gentle current which often finds its way into the ocean by several branches through a low-lying and marshy *delta*. The track worn or hollowed out by running water constitutes its *channel*, and the land that forms the margins of this channel is known as its *banks*—that on the right hand as we descend the current being termed the right bank, the left hand the left. The streams that enter any river or main current from either side form its *affluents* or *tributaries*, and the entire expanse of country drained by a river and its tributaries is said to be the *basin* of that river. An ideal line, connecting the ultimate sources of all the tributaries of a river, forms the *watershed* of its basin; and generally speaking, the ridge from which the streams of a country flow in opposite directions is the watershed of that region. As all the streams of a river-basin fall to the lower level of that basin, so several river-basins may descend to the still broader basin of some sea or ocean, and all such basins discharging themselves into the same sea constitute a *river-system*.

The river-systems are necessarily named after the great oceans into which they flow; and thus we have the Arctic, the Atlantic, Pacific, and Indian systems, together with a few inland systems whose streams flow towards certain depressed areas altogether cut off from connection with the ocean. These are the Aralo-Caspian basin, the Utah, the Mexican, the Bolivian, &c., whose waters flow inwards to certain lakes, and are thence carried off by evaporation. Where the slopes of a country are pretty uniform, the surface waters are at once carried off by streams and

rivers; but where any unusual depression occurs, there they accumulate and form *lakes* and *morasses*. Most of these lakes both receive and discharge running water; but some of a small size, being fed by springs and reduced by evaporation, neither receive nor discharge running water; while others again receive streams and rivers, but have no outlet—their surplus waters being carried off by evaporation. The former set of lakes are always fresh; the latter, like the Caspian, Aral, and Dead Sea, always less or more brackish and saline. The following table exhibits the salinity of several of these lakes as compared with that of the Mediterranean:—

<i>Percentage of</i>	<i>Mediterr.</i>	<i>Blk. Sea.</i>	<i>Azov.</i>	<i>Caspian.</i>	<i>Dead Sea.</i>	<i>Utah.</i>
Chlo. of sodium, . .	2.946	1.402	0.966	0.367	12.110	20.196
" magnesium, . .	.322	.130	.089	.063	7.882	.252
" calcium, . .	...	...	...	...	2.455	trace
" potash, . .	.050	.019	.013	.008	1.217	...
Br. of magnesium, . .	...	.005	.004	trace	.453	1.834
Sulph. of lime, . . .	.135	.011	.029	.049		
" magnesium, . . .	.248	.147	.076	.123		
Br. of sodium, . . .	.056	...	...	...		
Carb. of lime, . . .	.011	.036	.003	.017		
" magnesia, . . .	...	.021	.013	.001		
Perox. of iron, . . .	trace	...	...	...		
	3.768	1.771	1.193	.628	24.117	22.282

The student who desires more minute details on this portion of his subject will find ample data as to lengths and developments of rivers in the 'Royal Physical Atlas' of A. K. Johnston; as to towns and populations which their waters have attracted to their banks, in the 'Manual of Modern Geography' of Dr Mackay; as to hydrographical characteristics in general, in 'Das Wasser,' a German publication of great merit; and much information of an instructive kind may be gleaned from books of travel devoted to the exploration of such rivers as the Amazon, the Niger, Nile, Zambesi, Congo, and Yang-tse-kiang. Indeed, considering the attractions which all river-banks present to mankind, savage or civilised, there are few things so interesting in geographical descriptions as the ascents of rivers; and these the student should lose no chance of carefully perusing.

XI.

THE ATMOSPHERE—CLIMATOLOGY.

Nature and Constitution of the Atmosphere.

199. HAVING, in the preceding chapters, directed attention to the leading features of the Land and Water—the mountains, table-lands, and plains of the one, and the seas, lakes, and rivers of the other—we now proceed to consider the main relations of the Atmosphere or aerial envelope (Gr. *atmos*, vapour, and *sphaira*, a sphere) by which the whole is surrounded. What is the nature and composition of this envelope, what its capacity for heat and moisture, what are the motions to which, as an elastic fluid, it is subjected, and generally, what are its conditions as the great medium of climate (heat, cold, winds, rains, &c.) on which the Life of the globe is so intimately dependent? This varied subject of climatology belongs more especially to the science of Meteorology; but as an integral portion of the globe, and bearing on everything—organic and inorganic—that presents itself at the surface, the atmosphere and its principal phenomena become important themes to the student of Physical Geography.

200. As already stated, the atmosphere surrounding the globe, and partaking in all its motions of revolution and rotation, is an aeriform fluid consisting of nitrogen and oxygen gases—79 parts of the former to 21 of the latter by volume, or 77 to 23 by weight, together with a small and variable percentage (averaging .04, but ranging from .02 to .10) of carbonic acid gas, and occasionally of local and temporary impurities. These gases are merely in a state of admixture or diffusion, as is also the invisible vapour which less or more is ever present in the atmosphere. This special composition is alike indispensable to vegetable and animal life. Both animals and plants breathe, if we may so speak, the air; but while carbonic acid is exhaled by the former, it is

absorbed and assimilated by the latter, which in turn exhale oxygen for the requirements of the animal kingdom. By this means the balance of composition is harmoniously maintained, any local variations being too unimportant to affect the general result. Being an elastic or compressible medium, the air nearest the sea-level, pressed upon by all the superincumbent mass, is denser than that at considerable elevations; and by calculating the rate at which this rarity takes place, it is estimated that, at the height of 45 or 50 miles, the atmosphere becomes so rare or attenuated as to be all but inappreciable—and yet *not inappreciable*, for meteors become ignited in passing through it at the height of 90 and 100 miles. What the *absolute* height, or extension, may be, is still an undetermined problem—200 miles, 212 miles, and even greater altitudes being given, according to the principles on which the calculations are founded.

201. The mean pressure of the atmosphere taken at the sea-level is usually reckoned at $14\frac{3}{4}$ lb. avoirdupois (14.7304 lb.) upon the square inch—a pressure which, being equal on all sides, is insensible to living beings, the only inconvenience being experienced at great altitudes (5 or 6 miles), where the air becomes too rare and light to maintain respiration, or to retain sufficient heat for the functions of vitality. This aerial pressure is balanced by a column of mercury 30 inches in height; hence the construction of the *barometer*, and hence also the term *barometric pressure* as applied to the oscillations of the atmosphere, which sometimes rise above and at other times fall below this normal standard. The pressure or weight diminishing as we ascend, the barometric column will fall in proportion, and this fall (correction being made for varying effects of temperature) becomes a convenient measure of altitude. Thus, at the sea-level, near the foot of Chimborazo, Humboldt found that the barometer stood exactly at 30 inches, while at the elevation of 19,332 feet, to which he ascended, it fell to $14\frac{3}{4}$ inches. Again, under the normal pressure of the atmosphere, water at the level of the sea boils at the temperature of 212° Fahr.; but as the pressure becomes less, ebullition takes place sooner, and thus, as we ascend, the boiling-point diminishes, and may in like manner be taken as a measure of altitude. Of course, water at 212° and water at 190° (the boiling-point at 13,000 feet in the Andes) will produce very different effects—absolute temperature, and not mere ebullition or bubbling-up under diminished pressure, being the test of its heat.

202. As a general rule, the temperature of the air decreases in proportion as we ascend above the ordinary surface of the earth. One of the chief causes of this is the circumstance that only a

very small fraction of the sun's heat is arrested in its progress through the atmosphere, the greater part reaching to, and heating the surface of the earth. The lowest strata of the air in contact with that heated surface are consequently the warmest, while the highest strata, being farthest removed from it, are the coldest. As a property of the gaseous or aeriform nature of the atmosphere, the vapour or minute watery vesicles generated from the earth's waters by the heat of the sun, ascend and are diffused through its mass in an invisible state. The humidity of the atmosphere decreases with the height, and this in so rapid a ratio that at the altitude of 5 or 6 miles it is all but inappreciable. The vapour, invisible at first, becomes visible on being condensed by colder currents; hence arise fogs, mists, rains, snows, and other kindred phenomena. The large amount of watery vapour in the atmosphere acts as a cloak to prevent the free radiation of the heat of its lower strata; while its higher strata being almost wholly devoid of moisture, have nothing to prevent them from giving off what little heat they naturally receive from below into the intensely cold regions of outer space. The effective portion of the atmosphere, so far as its heat and moisture are concerned, lies therefore within a few thousand feet of the earth's surface, all above the limit of 5 or 6 miles being inoperative or nearly so in the production and regulation of climate. Like all gaseous bodies, air is expanded by heat and contracted by cold. In every region, therefore, where the surface of the earth is abnormally heated by the sun's rays, the air in contact with the ground expands, becomes lighter, and ascends into the higher parts of the atmosphere, the colder and denser air from the surrounding regions rushing in from all sides to supply its place. Again, the addition of watery vapour to the air lessens its density, and this in proportion to the temperature; so that in areas of excessive evaporation a similar ascending current is originated, and the heavier air of the colder regions flows in to fill up the vacancy. In both these ways currents or *winds* are generated in the atmosphere, and on these currents depend in great measure the essentials of climatic diversity.

203. With regard to the *functions of the atmosphere*, the following beautiful passages from the pen of our early friend and fellow-worker—the late Dr George Buist—will be fully appreciated by the student whose mind is duly alive to the chain of harmonies that links together the remotest members of our cosmical system: “We have already said that the atmosphere forms a spherical shell, surrounding the earth to a thickness which is unknown to us, by reason of its growing tenuity, as it is released from the pressure of its own superincumbent mass. Its upper surface can-

not be nearer to us than fifty, and can scarcely be more remote than five hundred miles. It surrounds us on all sides, yet we see it not; it presses on us with a load of fifteen pounds on every square inch of surface of our bodies, or from seventy to one hundred tons on us in all, yet we do not so much as feel its weight. Softer than the finest down, more impalpable than the finest gossamer, it leaves the cobweb undisturbed, and scarcely stirs the lightest flower that feeds on the dew it supplies: yet it bears the fleets of nations on wings around the world, and crushes the most refractory substances by its weight. When in motion, its force is sufficient to level with the earth the most stately forests and stable buildings, to raise the waters of the ocean into ridges like mountains, and dash the strongest ships to pieces like toys. It warms and cools by turns the earth and the living creatures that inhabit it. It draws up vapours from the sea and land, retains them dissolved in itself or suspended in cisterns of clouds, and throws them down again, as rain or dew, when they are required. It bends the rays of the sun from their path to give us the aurora of the morning and twilight of evening; it disperses and refracts their various tints to beautify the approach and the retreat of the orb of day. But for the atmosphere, sunshine would burst on us in a moment and fail us in the twinkling of an eye—removing us in an instant from midnight darkness to the blaze of noon. We should have no twilight to soften and beautify the landscape, no clouds to shade us from the scorching heat; but the bald earth, as it revolved on its axis, would turn its tanned and weakened front to the full and unmitigated rays of the lord of day.

“The atmosphere affords the gas which vivifies and warms our frames; it receives into itself that which has been polluted by use, and is thrown off as noxious. It feeds the flame of life exactly as it does that of the fire. It is in both cases consumed, in both cases it affords the food of consumption, and in both cases it becomes combined with charcoal, which requires it for combustion, and which removes it when combustion is over. It is the girdling encircling air that makes the whole world kin. The carbonic acid with which to-day our breathing fills the air, to-morrow seeks its way round the world. The date-trees that grow round the falls of the Nile, will drink it in by their leaves; the cedars of Lebanon will take of it to add to their stature; the cocoa-nuts of Tahiti will grow rapidly upon it; and the palms and bananas of Japan will change it into flowers. The oxygen we are breathing was distilled for us some short time ago by the magnolias of the Susquehanna and the great trees that skirt the Amazon and the Orinoco; the great rhododendrons of the

Himalayas contributed to it ; and the roses and myrtles of Cashmere, the cinnamon-tree of Ceylon, and the forest, older than the Flood, that lies buried deep in the heart of Africa, far beyond the Mountains of the Moon, gave it out. The rain we see descending was thawed for us out of the icebergs which have watched the polar star for ages, or it came from snows that rested on the summits of the Alps, but which the lotus-lilies have soaked up from the Nile, and exhaled as vapour again into the ever-present air."

Had the globe presented either one uniform surface of land or one uniform surface of water to the sun's rays, the interchanges of heat and moisture between the colder and warmer, the drier and moister regions of the atmosphere, would have been regular and continuous. But the earth's surface being composed of land and water in unequal proportions, and this land lying not only in irregular masses but presenting also irregular surfaces of highland and lowland, the movements of the atmosphere are so broken up and complicated that the winds and rains, the heat and cold, are rendered extremely variable—so variable, indeed, that Meteorology consists as yet more of collections of facts and approximations to results than of ascertained and definable laws. Under these circumstances we shall glance merely at the leading features of the atmosphere—its heat, moisture, and motions—as bearing more directly on the *climate*, or weather-conditions, if we may so express it, of the earth's various regions.

Heat of the Atmosphere.

204. In dealing with the subject of climate, the superficial or atmospheric temperature of the globe may be viewed as wholly dependent on the heat of the sun—the amount conveyed from within (paragraph 18) or radiated from the moon and other external sources being by far too feeble to have any perceptible influence. As is well known, the solar rays exercise the greatest effect within the tropics, where they fall vertically or nearly so on the earth's surface, and this effect gradually declines as we proceed through the temperate zones towards either pole. In other words, the higher the angle at which the sun's rays strike the earth the greater their heating power, and the lower the angle the less the amount of heat imparted. We feel the truth of this every summer day, when the sun is high above during the scorching noontide, and when his beams fall at a lower angle during the cooler afternoon. And the causes of these differences are evident at a glance. When the sun's rays are vertical, as at A

(see fig.), the amount of heat represented by the angle A B C is all concentrated upon the small space B C of the earth's surface. When the sun has declined to D, the same amount is necessarily spread out over the much larger space B E, each single spot

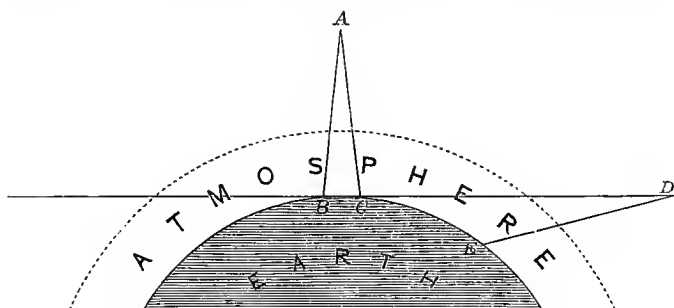


Figure showing the influence of the varying inclination of the sun's rays.

receiving a very much smaller proportion than before. Again, at A, the sun's rays pass through a comparatively thin film of moisture-laden atmosphere, and but little of their heat is arrested by it. At D, on the other hand, the thickness of the atmosphere through which the rays have to pass is immensely increased; much more heat is absorbed, and the quantity remaining to heat the surface of the earth at any single locality in the space B E is proportionally diminished. In this way it has been calculated that the portion of the earth's surface lying between $23^{\circ} 44' 40''$ on either side of the equator forms a belt within which the solar heat received is equal to what is received by all the rest of the world; hence the student will perceive the applicability of the terms "torrid," "temperate," and "frigid" zones. Keeping out of view all minor modifications produced by the peculiar disposition of sea and land, as well as by the sun's alternate passage to the northern and southern hemisphere along the course of the ecliptic, it may be received as the first great axiom, that the superficial temperature of the globe is highest under the vertical incidence of the sun's rays near the equator; and that it gradually becomes lower and lower as we proceed towards either pole, and this in proportion to the obliquity at which the heat-giving rays fall upon the surface.

205. As we have already indicated, there is a gradual decrease in the temperature of the air as we ascend from the level of

the sea to higher elevations. The rate at which this diminution takes place depends, as has been shown by Mr Glaisher's balloon experiments in 1863, on many correlative circumstances—dryness, moisture, currents, &c.; but, as a general fact, the decrease goes on as we ascend—and, from Professor Wahl's experiments, apparently more rapidly in the upper than in the lower strata of the atmosphere. The old rule of a *regular* decrease of 1° Fahr. for every 300 feet of ascent must therefore be abandoned, and the following generalisation be adopted—viz., that there is a decrease, but a *variable* one, for every 100 feet of ascent during the day up to 2000 feet, and a small but also variable increase up to the same height during the night, when radiation from the earth begins, and the heat is arrested by the vapours in the atmosphere. In this way—that is, by a general diminution of the temperature as we ascend—the lower plains of a region may be teeming with vegetation, while the higher mountains are enveloped in perpetual snow. We have thus two great causes affecting the superficial temperature of the globe—distance from the equator, and elevation above the level of the sea; so that at any given latitude it is much the same whether we travel towards the nearer pole or ascend a lofty mountain. In both we will meet with a gradually decreasing temperature, in both we will meet with corresponding changes in animal and vegetable life, and in both we ultimately reach a limit of perpetual ice and snow. In the case of elevation, this limit is known as the *snow-line*, at which the air in summer attains the temperature of freezing water; and though slightly modified by surrounding circumstances, it varies primarily with the latitude—ascending from the sea-level at either pole to 15,000 or 16,000 feet in the vicinity of the equator. In the case of horizontal extension, *the line of constantly frozen ground* differs in either hemisphere—that in the northern (see Map of Isotherms) assuming an irregular course, in consequence of the unequal distribution of sea and land, and that in the southern being less determinable in consequence of the greater expanse of Antarctic Ocean.

206. Another cause of variation in atmospheric temperature is the difference in the manner of reception and radiation of the sun's heat by the respective surfaces of land and water. The heat falling on the land is partly absorbed and conducted downwards into the soil, and partly radiated into the atmosphere. The amount absorbed will differ according to the colour, slope, and character of the land (dry, firm, and dark-coloured soils being most favourable for absorption); and according also as it is naked or shut out from the sun's rays by a covering of vegetation. The

amount radiated differs with almost every passing condition of the atmosphere—radiation going rapidly forward under a still, clear sky, while a cloudy atmosphere, or even a passing mist, serves to retard it. The greater quantity of heat absorbed by day is given off by night; and the amount accumulated during summer is returned to the atmosphere during winter. The depth thus affected by summer's heat or winter's cold will differ according to latitude, soil, and situation,—the soil in Siberia, for example, being never thawed beyond the depth of a few feet, while under the equator the sun's influence has been known to extend to the limit of 90; but, on the whole, it may be safely asserted that beyond 60 or 80 feet the temperature of the earth's crust is little or at all affected by external influences (see par. 17). Indeed, for all practical purposes, the superficial temperature of the land, as affecting climate, may be regarded as confined to a very few feet beneath the surface—the slow conducting power of the soil and capillary attraction of moisture from below combining to limit its downward tendency.

207. On the other hand, the heat that falls on the water penetrates to a considerable depth, is diffused by waves and currents, and accumulates within the upper waters of the ocean. The heat that falls on any zone of the land is absorbed and radiated wholly within that zone; whereas that falling on any zone of the ocean is diffused and interchanged between all the surrounding zones. As the specific heat of the ocean is much greater than that of the land, while it exposes more than thrice the surface to the sun's rays, it becomes, as it were, a great store-house of heat for the exigencies of the land. It is for this reason that islands and seabords possess a milder and more equable climate than the interior of continents—being warmer during winter and cooler during summer. The British Isles, with their comparatively cool summers and mild variable winters, are thus said to possess an *insular climate*; while the interior of Germany, with its excessively hot summers and cold winters, is said, on the contrary, to possess a *continental climate*. In tropical latitudes, unaffected, of course, by winter, the interior of continents is always much warmer than the sea-coasts and adjacent islands. It is also for this reason that the northern and southern hemispheres, having unequal distributions of sea and land, are differently affected in their zones of climate—the greater extent of land in the northern imparting to it, as it were, a continental climate; while the greater expanse of ocean in the southern confers on its similar latitudes more of an insular climate. It is, further, to this unequal specific heat of land and water that we owe the

phenomena of sea and land breezes. During day the atmosphere immediately above the land is heated to a far higher temperature by terrestrial radiation than that above the ocean, hence the cooler sea-breeze sets in towards the land to restore the balance; while during the absence of the sun the more rapidly cooling land-atmosphere sets out as a land-breeze towards the more slowly cooling surface of the ocean. In fine, it is mainly owing to the unequal distribution of sea and land, and to the different modes in which these two elements are affected by the sun's heat, that we owe the great essentials of climatic diversity—the air and ocean-currents, the vapours and rains, of one region, varying from the winds, currents, and moisture of another.

Moisture of the Atmosphere.

208. Whatever the temperature of the air, it is incessantly receiving *moisture* from the surface of the land and water. This vapour arises and is diffused through its mass in an invisible form, and becomes visible only when condensed into mists, fogs, rains, and snows. It arises alike from land and water, but most copiously and persistently, of course, from the surface of the water, whether in the liquid condition of lakes and seas, or in the solid state of ice and snow. The superficial moisture of the land, unless where clothed with vegetation, is rapidly converted into vapour; but the supply from this source is irregular and limited compared with that derived from the water. Surface for surface, salt water is less vaporisable than fresh; hence a slight check to evaporation from the vast and extended surface of the ocean. It arises from rivers, lakes, and seas in every latitude, but most abundantly, of course, within the tropics, where the sun's heat is the greatest. So great is the evaporation within that zone, that it has been estimated as annually sufficient to reduce the surface of the sea to a depth of 12 or 16 feet—a waste, of course, that is incessantly counterbalanced by influx from other latitudes. The warmer the air the greater its capacity for moisture. When the air contains as much vapour as it can retain in the gaseous state, it is said to be saturated. Any decrease in the temperature of the air in this condition reduces its point of saturation; the moisture in excess is at once condensed, and becomes visible in the form of mists, fogs, dew, or rain.

209. As in the case of other meteorological phenomena, the circumstances connected with the production and retention of atmospheric vapour are extremely complicated: but in general terms

it may be stated that heat is the grand promoter of evaporation ; that a gentle current of air, by removing the pressure of the vapour as it is formed, is more favourable than a stagnant atmosphere ; that it is retarded by moist and cloudy conditions of the air, even though the sensation of heat be considerable ; and that its amount is greatest between March and November, and least between November and March. Vapour, like glass, allows the solar heat to pass through it ; but non-luminous heat, and therefore the non-luminous heat radiated by the earth, is conserved or kept in by the vapour surrounding the earth. “No doubt,” says Professor Tyndall, “can exist of the extraordinary opacity of this substance to the rays of obscure heat ; particularly such rays as are emitted from the earth after being warmed by the sun. Aqueous vapour is a blanket more necessary to the vegetable life of England than clothing is to man. Remove for a single summer night the aqueous vapour from the air which overspreads this country, and you will assuredly destroy every plant capable of being destroyed by a freezing atmosphere. The warmth of our fields and gardens would pour itself unrequited into space, and the sun would rise upon an island held fast in the iron grasp of frost.” As previously mentioned, the humidity of the atmosphere is confined chiefly to its lower strata ; and so rapidly does the quantity diminish as we ascend, that at the height of 5 or 6 miles it becomes all but inappreciable. The quantity of moisture evaporated from the surface of the globe may differ from day to day, and from year to year ; but on the whole, and for any given number of years, it is returned again in the state of dew, rain, hail, or snow. Understanding the general conditions of the atmosphere as regards its heat and moisture, we may now proceed to its special effects in the production of winds, rains, and other kindred phenomena.

Winds—their Characteristics.

210. As already explained, any current of the atmosphere produced by inequality of temperature or density is termed a *wind*—the denser and colder air rushing in to supply the place of the lighter and warmer. In other words, *wind is air in motion* ; and the most frequent cause of such motion is disparity of temperature between adjacent districts. As inequality of temperature is ever arising alike from general and from local causes, the occurrence of winds is incessant and universal, either along the earth's surface, or in the higher strata of the atmosphere. While

the colder current is flowing *below* from the colder to the warmer region, a warm current is floating *above* from the warmer to the colder. As the homogeneity of the ocean is maintained by its currents, so the equilibrium and uniformity of the atmosphere is preserved by its winds. These winds, having different times, directions, and characters, are necessarily arranged into different classes, and distinguished by various designations.

211. As regards times, those blowing constantly in one direction between, and within a few degrees beyond, the tropics (the Trades), are spoken of as *permanent winds*; those blowing at certain periods (the Monsoons, &c.), as *periodical*; and those obeying no fixed period, as *variable*. As concerns direction, they are distinguished by the points of the compass as North, South, East, West, South-west, South-south-west, &c., according to the quarter from which they blow. And as regards inherent or climatic character, they are cold or hot, dry or moist, gentle or boisterous, healthful or unhealthful, according to locality and other accompanying conditions. One of the most obvious characteristics of winds is their velocity, which may vary from a few miles to upwards of a hundred miles an hour; and between these extreme rates we have every variety, from the gentlest zephyr to the most violent hurricane. According to meteorological authorities, a velocity of 7 miles per hour is regarded as a gentle air; of 14, as a light breeze; of 21, a good sailing breeze; of 41, a gale; of 61, a great storm; of 82, a tempest; and of 92, a hurricane, producing universal devastation—tearing up trees and sweeping away buildings. Or more minutely, according to their *velocity* and *force*, they have been arranged as follows:—

Velocity in Miles per Hour.	Force in lb. Avoird. per Square Foot.	Common Appellation.
1	.005	Breath of air.
4	.079	Gentle air.
5	.123	Light wind.
10	.492	Brisk wind.
15	1.107	Light breeze.
20	1.968	Brisk breeze.
25	3.075	Stiff breeze.
30	4.429	High wind.
35	6.027	Gale.
40	7.873	Strong gale.
50	12.300	Storm.
60	17.715	Great storm.
80	31.490	Hurricane or tempest.
100	49.200	Violent hurricane.

212. In whatever character they occur, winds are important agents in the production and modification of climate. By their agency the moist and heated atmosphere of one region is transferred to another; and on their agency also depend, in a great measure, those currents of the ocean which are ever producing interchanges between the colder and warmer surface-waters of different latitudes. Besides these great climatological functions, they are intimately concerned in the production of rains and other aqueous phenomena; while their incessant commotions tend to preserve the atmosphere in ever-healthy equilibrium. They are the great bond, as has been well observed, between the land and water surfaces—transferring the moisture of the one to the thirsty uplands of the other, and the dry cold air of the former to disperse and rarefy the humid and depressing atmosphere of the latter. Geologically, winds have considerable effect in removing, piling up, and reassorting all loose superficial matters, as the sand-dunes of the sea-shore and the sand-drift of the desert; while through the agency of the ocean-waves, which are created by their power, important changes are produced along every shore of the world. In their gentler manifestations they assist in the fertilisation of plants and in the dispersion of their seeds; while in their fiercer demonstrations their track is marked by ruin and devastation. By their impulse the commerce of distant nations is wafted from shore to shore; and fickle and fitful as they may appear, man not unfrequently avails himself of their power to turn the wheels and shafts of his machinery.

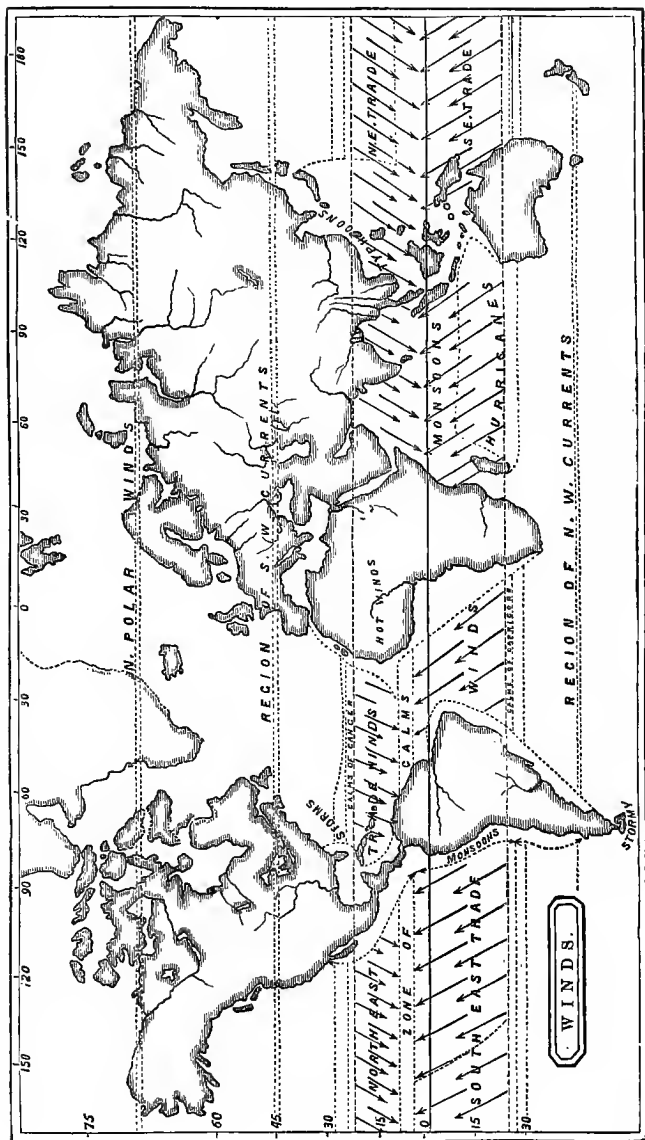
Permanent Winds—the Trades, &c.

213. The most remarkable of the *permanent, constant, or perennial* air-currents are the TRADE-WINDS (so called from their influence on the trade or commerce of the world), which, within the torrid zone and a few degrees beyond it on either side, are ever sweeping round the globe in a westerly direction. This is occasioned by the fact that the region near the equator is most intensely heated—the other zones becoming colder and colder towards either pole. Under these circumstances, the air of the torrid zone becomes rarefied and ascends, while the colder and denser air sets in from either side to supply the deficiency. There are thus generated two great sets of currents—colder under-currents setting in towards the equator respectively from the north and south, and warm upper-currents flowing off from the equator towards either pole. If, then, the atmosphere were

subject to no other influence than temperature, a *north wind* would always prevail along the earth's surface in the *northern hemisphere*, and a *south wind* in the *southern hemisphere*. But as the polar currents proceed towards the equator, they gradually come into zones having a greater velocity of rotation, and thus they assume a more westerly direction (as exhibited in the accompanying Sketch-map), so as to become a *north-east wind* in the northern hemisphere, and a *south-east wind* in the southern.

"Since the earth," says Sir John Herschel, "revolves about an axis passing through the poles, the equatorial portion of its surface has the greatest velocity of rotation, and all other parts less in the proportion of the radii of the circles of latitude to which they correspond. But as the air, when relatively and apparently at rest on any part of the earth's surface, is only so because in reality it participates in the motion of rotation proper to that part, it follows that when a mass of air near the poles is transferred to the regions near the equator by an impulse urging it directly towards that circle, in every point of its progress towards its new situation it must be found deficient in rotatory velocity, and therefore unable to keep up with the speed of the new surface over which it is brought. Hence, the currents of air which set in towards the equator from the north and the south must, as they glide along the surface, at the same time lag or hang back, and *drag upon* it in the direction *opposite* to the earth's rotation—*i.e.*, from east to west. Thus these currents, which but for the rotation would be simply northerly and southerly winds, acquire from this cause a *relative* direction towards the west, and assume the character of permanent north-easterly and south-easterly winds."

214. In the Pacific, the north-east trade-wind may be said to prevail between the 25th and 2d degree of N. lat.; while the south-east trade ranges more widely between the 10th and 21st of S. lat. In the Atlantic, on the other hand, the former is comprised between the 30th and 8th degree of N. lat., and the latter, within the 3d of N. and the 28th of S. lat. These limits, however, are not altogether stationary, but depend on the seasons—advancing towards the north during the summer of the northern hemisphere, and receding to the south as the sun withdraws to the southern tropic. Within these fluctuating zones, which may be estimated at 1000 miles in width, the trade-winds are steady and perennial, travelling at the rate of from 10 to 20 miles an hour, and wafting onwards in safety the merchandise of the globe. As they approach the continents, their courses become interrupted, in consequence of the unequal heat-



ing of the land and water surfaces ; hence within these coast-areas they assume the character of periodical rather than of constant currents, being deflected at certain seasons from their normal directions.

215. As the north-east and south-east trades approach the equator of temperature, their currents begin to fail, and this effect, augmented by the upward tendency of the highly heated air of that region, produces a zone or belt of calms, which fluctuates a few degrees north and south, according to the seasons. If the approaching trades be equally reduced in any locality, a dead calm will be the result ; but as this is seldom the case, the zone is also characterised by short gusty winds, which vary in force and direction according as either main current prevails. This *zone of calms and variables*, as it is termed, is further characterised by the frequency and intensity of its thunderstorms—the crossing and collision of currents of unequal densities being favourable to the manifestation of electrical phenomena. In the Atlantic, the region of calms (see Sketch-map) ranges in August between 3° and 12° N. lat. ; but in February it extends from $1^{\circ} 15'$ to 6° N. lat. A portion of this zone near the Cape Verde Isles is known to sailors as the “rainy sea ;” and is described by M. Guyot as “a region doomed to continual calms, broken up only by terrific storms of thunder and lightning, accompanied by torrents of rain. A suffocating heat prevails, and the torpid atmosphere is disturbed at intervals by short and sudden gusts, of little extent and power, which blow from every quarter of the heavens in the space of an hour—each dying away ere it is succeeded by another. In these latitudes vessels are sometimes detained for weeks.” In the Pacific, the region of calms is comprised within the 2d degree of north and south lat., near Cape Francis and the Galapagos Islands—a narrow belt of 300 miles or thereby separating the two trades, and being characterised by the same phenomena as the calm zone of the Atlantic.

216. Besides the trade-winds, which are the most persistent of all aerial currents, there are certain winds in the higher latitudes that also blow with considerable continuity. The heated air which ascends from the tropics, and flows off towards either pole, gradually descends as it proceeds ; but as it passes from latitudes having a high to others having a low rotatory velocity, it is deflected from its original course, and assumes a south-easterly direction in the northern hemisphere, and a north-easterly in the southern. In this way the prevailing winds in the higher latitudes of the northern hemisphere are from the *south-west*, and those in the southern hemisphere from the *north-west* ; and though many

causes—unequal distribution of sea and land, position of continents, irregularity of land-surface, &c.—tend to disturb this continuity, still, on the whole, there is a marked predominance of westerly winds. In our own islands, the fact must be sufficiently obvious to every observer; in the North Atlantic, the average packet-voyage from New York to Liverpool is 23 days, while the return voyage requires 40 days; and in the vicinity of Cape Horn, westerly winds are three times more frequent than those from an easterly direction.

217. Among the constant currents of the atmosphere must also be enumerated the *north and south polar winds*, which, as mentioned in the theory of the trade-winds, are continually flowing north and south from either pole. And further, as an under current almost invariably implies the existence of an upper current in a contrary direction, we may notice also the *upper west wind of the tropics*, which, high above the trades, seems constantly flowing in an opposite direction. Proofs of these upper tropical winds, or *anti-trades* as they are sometimes termed, are found in the circumstance that dust ejected from the volcanoes of the West Indies has fallen on ship-deck several hundred miles to the eastward; and also in the often-observed fact, that a similar wind prevails near the summit of Teneriffe (12,000 ft.), while the regular trade-wind is blowing from an opposite direction below.

“The existence of the upper trade-wind, coming from the west, or of the return trade-wind, which has often been doubted, seems to be proved in the Atlantic,” says M. Guyot, “by two facts often cited and very conclusive. The volcano of the island of St Vincent, belonging to the lesser Antilles, in one of its eruptions hurled a column of volcanic cinders to a great height in the atmosphere; the inhabitants of Barbadoes, situated east of St Vincent, saw with astonishment the cinders falling upon their island. The 25th of February 1835, the volcano of Cosiguina, in Guatemala, threw into the air such a quantity of cinders that the light of the sun was darkened during five days; a few days after, they were seen to cover the streets of Kingston, in Jamaica, situated 800 miles north-east of Guatemala. In these two cases it is evident that the cinders had reached the region of the upper trade-wind, and had been carried by it from west to east, in the opposite direction to the lower trade-wind. At the summit of the peak of Teneriffe, again, most travellers have found a west wind, even when the north-east trade-wind prevailed on the seaboard.”

Periodical Winds—the Monsoons, &c.

218. Of the *periodical winds*, the most important are the **MONSOONS** (from the Malay word *moussin*, signifying seasons), which in certain countries within and near the tropics blow from a certain quarter for one-half the year, and from an opposite point during the other half—the period of change being marked by calms, tempests, and variables. In other words, the monsoons are but the trade-winds interrupted in their regular action by the geographical peculiarities of the regions in which they occur. From April to October, the *south-west* monsoon prevails north of the equator, and the *south-east* in the southern hemisphere; but from October to April the *north-west* monsoon blows south of the equator, and the *north-east* in the northern hemisphere. Of course, the farther from the equator, the later in the season will the south-west and north-west monsoons occur; and thus it happens that in India, at Anjengo, on the Malabar coast, $8^{\circ} 30'$ N. lat., the south-west monsoon commences as early as the 8th of April; at Bombay, 10° N. lat., about the 15th of May; in Arabia it commences a month earlier than on the coast of Africa; and in the northern part of Ceylon, fifteen or twenty days earlier than on the coast of Coromandel.

219. The cause of the monsoons is to be sought in the effect produced by the sun during his apparent annual progress from one tropic to the other. In summer the great elevated expanse of land in Central Asia becomes excessively heated under the rays of an almost vertical sun. The air above expands, and a region of low atmospheric pressure is formed, into which the colder and denser air from the surrounding areas flows in a spiral form, moving in a south-west direction across India and China from the Indian Ocean. In winter we have exactly the reverse of this. The high and dry table-lands of Central Asia become excessively cooled, the air above is condensed and flows outwards in a spiral form (see par. 224) upon the warmer areas around, blowing across north-east Siberia from the north-west, across China from the north, and across India from the north-east. Similar periodic winds or monsoons, due to corresponding causes, occur in other regions; but none are so well marked as those of the Indian Ocean. The winds of Australia blow landwards in the hot months, and seawards in the cold season. Off Mozambique the trades change to the east during summer; and the south-east trade-wind of the Atlantic is changed into a south-west monsoon on the Guinea coast, and a north-west monsoon off Brazil.

220. Equally remarkable for their persistency, though local in their areas and limited in their times, are the *land and sea breezes*, which occur on almost every seaboard, but most notably, of course, within the tropics. As formerly explained, these breezes arise from the unequal heating of the land and water surfaces, and become most decided where this inequality is greatest. During day the land-surface, from its low conducting power, acquires a more elevated temperature than the adjacent waters, and the air above it, partaking of this heat, becomes rarefied and ascends, while the cooler and denser air from the ocean sets in as a *sea breeze* to restore the equilibrium. This sea-breeze, especially in tropical latitudes, commences about nine in the morning, gradually increases in force till the middle of the day, and falls away as the sun declines in the afternoon. As evening approaches, the air over the surface of the land becomes more rapidly cooled by radiation than that over the water, and then a cool *land-breeze* sets out towards the ocean, blows freshly during the night, and dies away towards morning, when the sea-breeze again commences. The extent of these breezes is extremely variable. In some localities they blow only for a few miles within and outside of the shoreline, while in others their bracing and refreshing influence is experienced for many leagues in either direction.

Variable Winds.

221. Owing to the mobility of the atmosphere, and the many causes that may temporarily affect its temperature and density, the *variable winds* are exceedingly numerous and capricious—so capricious, that “fickle as the wind” has become an established simile in every extra-tropical country. We say *extra-tropical*, for within the tropics the trades and monsoons are the prevalent winds, and these, as we have seen, maintain a remarkable degree of permanency or periodicity. But in extra-tropical regions, where the force of the permanent winds becomes feeble, a thousand causes (as unequal distribution of land and water, nature of soil, irregularity of surface, &c.) occur to disturb these currents, and thus almost every district has its temporary winds—varying in direction, force, and duration. Fickle and uncertain as they may appear, they are, nevertheless, the results of law and law-directed forces. They all have their origin in local differences of atmospheric pressure—the wind blowing from a region where there is a surplus to one where there is a deficiency of air, and entering upon it in a spiral manner, due in part to its own

impetus, and in part to the rotation of the earth. This will be noticed more fully under the heading of Storms (par. 224). It has been held that in the middle latitudes of the northern hemisphere there are, properly speaking, only two normal winds—that of the north-east, and that of the south-west—the former being the cold polar hurrying towards the equator, and the latter the warm equatorial trending towards the poles. “The winds blowing in other directions are local winds, or transition winds, from one of the general currents to the other; and Professor Dove endeavoured to prove that in Europe, at least, these winds succeed each other in an order always the same, which he has called the law of rotation of the winds. This will be easily understood if we remember that in advancing along their course the south-west tends always to become more west, and the north-east more and more east; we shall see that the result of this disposition ought to be, whenever they meet and change places, a rotation from west by north to east, and from east by south to west. In the place of the conflict of the two currents, the wind will then blow successively from three different regions, and in this order, until it is established in the direction of that one of the currents which has overpowered the other. But no one of these transition winds blows for any great length of time. In the southern hemisphere the order of succession is the reverse.”

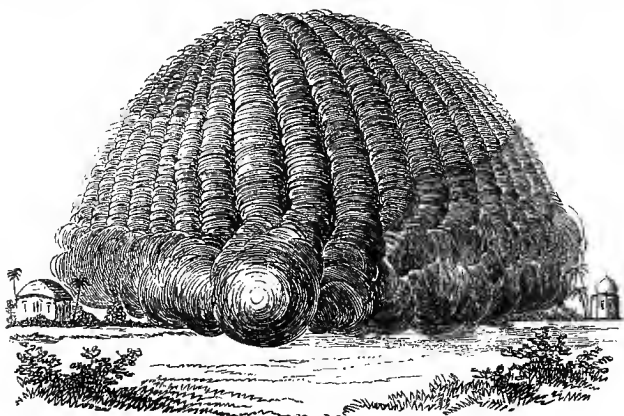
Referring to the winds of the northern hemisphere, the eloquent author of ‘Earth and Man’ has the following suggestive remarks: “This conflict of polar and equatorial winds, opposite in character and direction, gives to our climate one of its most characteristic features, that changeableness, that extreme variety of temperature, of dryness and of moisture, of fair weather and of foul, that uncertainty of the seasons, which always keep the merchant and the farmer in anxious suspense, between the hope of a good harvest and the fear of a dearth. Not only are the variations in the same year considerable, but they are still more so from one year to another. The system of these currents oscillates from east to west, and changes place. The polar winds will prevail in a country, and will endanger the crops by the prolonged dryness of their atmosphere; while further east or west the trade-wind will spread fertility by its beneficent rains. Or the opposite: the south winds acquire such a preponderance, that the harvests perish by the moisture; while, at a somewhat greater distance, on the limit of the same wind, Nature lavishes all her treasures upon the labourer. It has been remarked that a mild winter in Europe corresponds frequently to a severe winter in America and Asia; while the mildness of the winter in America affords a presumption of a

colder winter on the other side of the Atlantic. The years 1816 and 1817 were marked, as is known in the history of Europe, by a general famine and distress. The wet was such that the harvests failed entirely. But the south-west wind, which blew without cessation over the western part of the continent, and which drenched it in its vapours, did not extend beyond Poland; and it was the south of Russia whose corn supported famished Europe for many long months. Then was revealed the commercial importance of those countries, previously unknown, and constantly increasing since. Who does not still remember the immense impulse given to the commerce between Europe and America by the drought of 1846, which damaged the corn-crop in Europe while America had an abundant harvest? These examples alone tell us the important part played in the life of nations by those variations of the atmospheric currents belonging to our temperate countries."

222. Generally speaking, in the higher latitudes of the northern hemisphere, a south wind is warm and moist, because it comes from warmer regions, and passes over a greater extent of ocean; while, on the contrary, and for opposite reasons, a north wind is cold and dry. It is for this reason that the westerly and south-westerly winds of Europe are humid and genial, and the north and north-easterly hard and ungenial. These major currents are of course much modified in their passage over certain localities, and hence the various characteristics assigned to the *Etesian Winds* (Gr. *etesios*, annual) that prevail very much in early summer all over Europe. One of the most noticeable of local winds is the *Simoom* (Arabic, hot and poisonous)—a hot suffocating blast, that occurs in most countries bordering on sandy deserts, especially in certain parts of Asia and Africa, where its temperature has been noted as high as 120 and 130 degrees. Coming from the arid desert, and laden with the minutest particles, it often gives a reddish colour to the atmosphere, and thus forewarns the traveller to take shelter from the approach of its pestilential breath. In Turkey it is called the *Sameli*; in Egypt, *Khamsin* (fifty), because it usually continues fifty days; and in Guinea and Senegambia, *Harmattan*. The *Sirocco* (Arabic) is another hot, parching wind, that occasionally passes over Sicily and adjacent districts, and is supposed to originate in the Sahara, or great burning desert of Africa. The *Solano* (Lat. *sol*, the sun) is a similar south-west wind that occasionally visits the Spanish peninsula, and, blowing from the direction of the African deserts, is regarded as a modified sirocco. Indeed, this southern wind is felt more or less along the whole northern shores of the Mediterranean, and receives different names in the respective countries—*Föhn*, for

example, in Switzerland,—over which its warm enervating influences are experienced, and in which it occasionally causes rapid and destructive meltings of the Alpine snows and glaciers.

223. In Buenos Ayres, *Pampero* is the name given to a violent west wind, which, traversing the arid plains of the Pampas, raises whirlwinds of dust, and carries them forward to the coast of the Atlantic. The pamperos seem to be portion of the return or north-west trade-winds. In Peru, between the Cordilleras and the Andes, at the height of 12,000 feet, are vast tracts of desolate table-land, known by the name of the *Puna*. These regions are swept for four months in the year by piercing cold winds (the *Puna winds*) from the snowy peaks of the Cordilleras, which are



Dust or Sand Storm.

so extremely dry, and absorb moisture with such rapidity in their passage, as even to prevent putrefaction in dead animal bodies. A similar north-east mountain wind, under the name of *Bise* (Fr.), descends in spring and early summer from the snow-covered Alps, and occasionally carries its chilling influences far into the southern provinces of France.

Storms.

224. In addition to the variable winds already noticed, which either recur at tolerably regular intervals, or are confined to definite tracts upon the earth's surface, there occur in all countries violent commotions in the atmosphere, generally sudden in their

appearance, and most destructive in their effects. These are usually classed under the general title of *Storms*. Like all other winds, they are due to the aerial currents set up by a want of equilibrium between the weight of the atmosphere in adjoining areas. When from some cause the air in any locality becomes rarefied, it ascends, and the weight of the atmospheric column below is diminished. The colder and denser air of the surrounding areas at once rushes in from all sides to supply the deficiency, and a wind is generated of an intensity proportioned to the difference between the atmospheric pressures, which continues until equilibrium is restored. These incoming currents of air do not pass in straight lines to the centre of the area of low atmospheric pressure, but circle round it in an ever-narrowing spiral, gradually ascending as they approach the centre. Here their mutual pressure causes a calm, and they rise and flow upwards and outwards into the higher regions of the atmosphere. This incoming spiral or vorticose movement is termed a *Cyclone* (Gr. *kuklos*, a circle or whirl); while the corresponding outflowing motion from the areas of high pressure is termed an *Anticyclone*. In the northern hemisphere the rotation of the currents of air in a cyclone is from right to left, contrary to that of the hands of a watch. This, like the direction of the movement of the trade-winds already explained, is a necessary result of the earth's rotation from west to east. The incoming air-currents start from all directions towards the centre of the cyclone, and were the earth stationary, they would all meet and neutralise each other at the centre; but as the velocity of rotation of the earth's surface decreases as we pass from the equator to the poles, the wind approaching the disturbed area from the south reaches it with a greater easterly velocity than that of the latitude, and thus makes its appearance as a south-west wind. For a corresponding reason, the northerly currents arriving with a less easterly velocity than that natural to the area, appear to lag behind, and thus form a north-east wind. In this way a gyratory movement of the air is set up, the direction of which is from left to right. In the southern hemisphere, for a corresponding reason, the cyclone rotates from right to left. In addition to this rotatory movement, cyclones have a generally progressive movement in some definite direction, the centre of the storm moving onward at a rate of from 15 to 30 or even 45 miles an hour. With very few exceptions, British storms come from off the Atlantic Ocean—the centre of the storm area passing north of Ireland and Scotland, and leaving Europe by way of the North Cape; or crossing the central parts of Ireland and England, the North Sea, Denmark, and the Baltic, and dying away in the

plains of Russia : the former direction is by far the more common. The area of country affected by a storm is of a circular or ellipti-

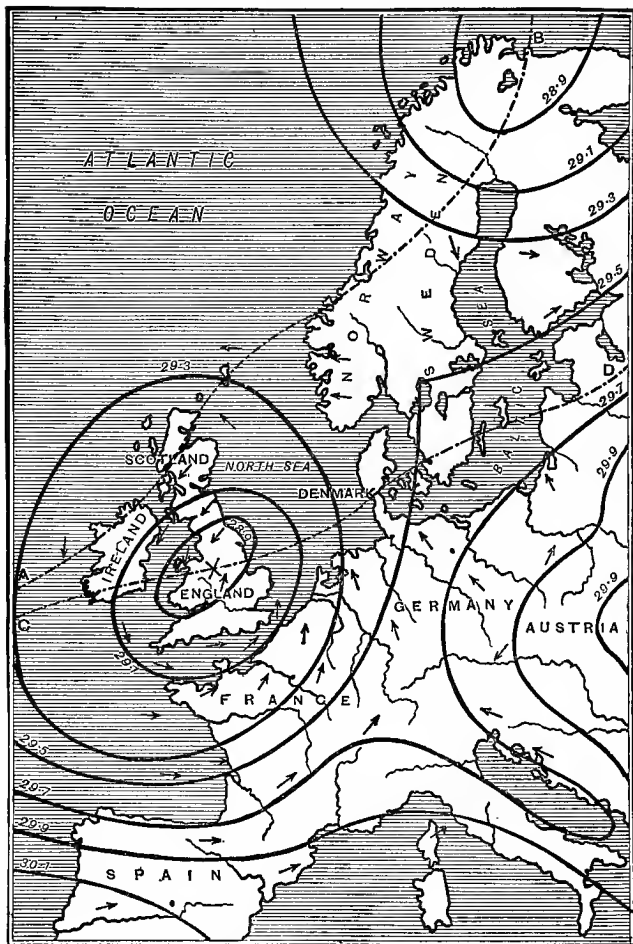


Figure showing Storms crossing British Islands.

cal shape, and is seldom less than 600 miles in diameter, averaging twice that amount. The force of the wind is strictly proportioned

to the difference between the barometric pressure at the centre of the cyclone and that of the neighbouring areas: where that difference is small, the resulting breeze is light; where it is large, the wind increases to a gale, blowing a velocity of from 60 to 70 miles an hour, while occasional gusts may have a speed of from 100 to 150 miles in the same time.

225. In the accompanying figure (Fig. p. 230) we have a synchronous chart of Western Europe, showing the barometric pressure and the direction of the wind when a storm is passing over the British Islands. The dark circles represent lines of equal barometric pressure, and are drawn through those points where the weight of the atmosphere is the same. From the arrangement of these lines upon the map, it will be seen that we have here evidence of two cyclones and two anticyclones. One of these cyclones (or storm-areas of low barometric pressure) is partly seen passing off into the Arctic Ocean to the north of Norway, having previously travelled across the north of Scotland and Ireland, along the dotted line A B. A second cyclone forms a storm-area extending completely round the British Islands, having its centre about the middle of England, and travelling slowly north-eastward along the line C D. Portions of two anticyclones (or areas of high pressure) are seen in Spain and Austria, and from these the wind rushes in, in a spiral course, to the storm-area of Britain. From the disposition of the small arrows, showing the direction of the wind, it is clear that the atmosphere surrounding the British Islands is whirling round in a spiral form from left to right, — blowing eastward in the Channel, northward in the German Ocean, westward in Scotland, and to the southward in Ireland. The winds blow their fiercest in the north of England, the Channel, and the Bay of Biscay, where the barometric lines are crowded together, and the difference in the weight of the atmosphere in neighbouring localities consequently very great in amount. To the north and west of Ireland, and in central Norway and Sweden, the widening of the barometric lines shows that the atmospheric disturbance is small, and there consequently the winds are comparatively light and gentle. The most violent and destructive of these local storms are the *Hurricanes* of the tropical regions. These have been most fully studied in the North Atlantic, where they generally follow a north-west course roughly parallel to the curved line formed by the seaward edges of Hayti, Cuba, and Florida. They blow with a velocity of from 80 to as much as 150 miles an hour, hurling the waters of the ocean upon the land, and committing the most fearful devastation in their course. The corresponding hurricanes of the southern

hemisphere cross the central parts of the Indian Ocean in a south-westerly direction towards the Island of Madagascar. The name *Typhoon* is given to similar hurricanes which occur in the China

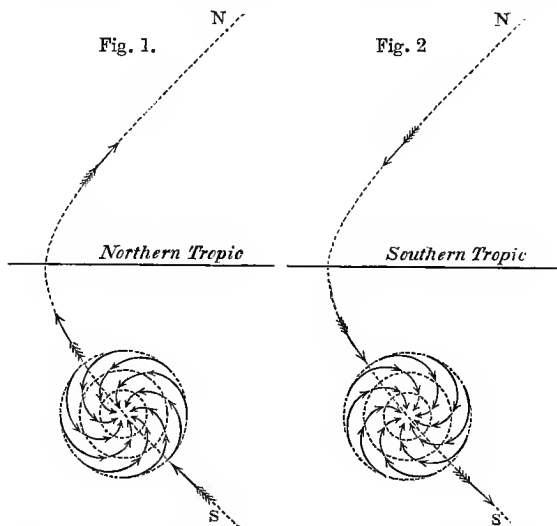


Fig. 1.—General direction and rotation of Hurricanes in the Northern Hemisphere.

Fig. 2.—General direction and rotation of Hurricanes in the Southern Hemisphere.

Sea and its neighbourhood, from June to October. They generally sweep in a south-west direction parallel with the coast of China, dying out as they reach the confines of the Indian Ocean. In all these hurricanes the same law of rotation obtains as that already indicated—the storms of the southern hemisphere rotating with the sun, those of the northern hemisphere moving in the contrary direction. The phenomena known as Whirlwinds, Tornadoes (Span. *tournar*, to turn), are merely local and violent cyclones of small diameter. Their occurrence at sea produces *waterspouts*, and on the sands of the desert *sand-pillars*, *sand-storms*, &c. Some of these whirlwinds have their origin in the meeting of contrary winds, and their direction of rotation is determined by the relative strength of the opposing currents. Others are caused by the eddies formed between the ascending columns of air rising from neighbouring spots unequally heated by the rays of the sun.

XII.

THE ATMOSPHERE—CLIMATOLOGY.

Dews, Fogs, Mists, Clouds, &c.

226. CLOSELY connected with the winds, and greatly influenced in their character by them, are the dews, rains, snows, and other aqueous phenomena which enter so largely into the determination of climate. The consideration of these subjects belongs especially to the province of Meteorology, but as much may be here recapitulated as will enable the student to trace their connection with the subject of Physical Geography. As already stated, insensible vapour to a greater or less amount is always present in the atmosphere as one of its accidental ingredients. The warmer the air the greater its capacity for this moisture; hence the greater amount taken up during the heat of the day. After sunset the earth loses much of its heat by radiation. The lowest stratum of the air in contact with the ground is cooled by it. Its point of saturation is consequently lowered, and it deposits that portion of its moisture which it is no longer able to retain in the gaseous state in the form of dew. Dew is, therefore, the moisture insensibly deposited from the atmosphere resting on the surface of the earth; and what is termed the *dew-point* is that temperature of the atmosphere at which dew begins to be precipitated. The quantity of dew deposited during any night may be ascertained by a *drorometer* (Gr., dew-measurer); but perhaps the most simple process is to expose to the open air bodies like locks of wool, whose exact weight is known, and then to weigh them afresh after they are covered with dew.

227. Dew never begins to be deposited upon the surface of any body until its temperature is below the dew-point of the contiguous atmosphere; and the quantity deposited depends chiefly

upon the humidity, serenity, and tranquillity of the atmosphere, as well as on the constitution, surface, and locality of the bodies receiving the moisture. Still, clear nights are therefore more favourable for the deposition of dew than windy and cloudy ones; and all substances like glass, silk, wool, grass, &c., whose radiating power is great, and conducting power small, are naturally most copiously bedewed; while substances like rocks and metals, which possess opposite qualities, contract but little dew. Bodies freely exposed to the atmosphere are more rapidly bedewed than those in any way screened or sheltered; and those near the soil more copiously wetted than such as are placed only a few inches higher. It is thus that the grassy turf is often pearly with dew while the taller herbage is comparatively dry; and the open country refreshed when the fall within towns is imperceptible. In temperate zones, where the frequent interchange of sun and shower preserves the earth from the extremes of heat and moisture, very little dew is deposited; but in tropical regions, where the day-heat is excessive, and no rain falls for months, the dews are most abundant and refreshing. But for this beneficent arrangement many intertropical countries would be altogether sterile and barren of vegetation. It must be remembered, however, that over arid deserts, where the air is excessively dry, there will be little or no dewfall, no matter what the intensity of nocturnal radiation. And in contrast to this it may be noticed that (all other things being equal) the most abundant dews occur in the neighbourhood of coasts, lakes, and rivers, where the atmosphere is in general more highly charged with moisture.

228. When the temperature of the air is reduced below the point of saturation, the moisture becomes visible, and appears as *fogs*, *mists*, and other kindred phenomena. These fogs occur most abundantly along the courses of rivers, on mountain-sides, over shoals and banks at sea, and generally along the sea-boards of continents and islands; and this obviously in consequence of the unequal temperature of the contiguous lands and waters. "In countries," says Kaemtz, "where the soil is moist and hot, and the air moist and cold, thick and frequent fogs may be expected. This is the case in England, the coasts of which are washed by a sea at an elevated temperature. The same is the case with the polar seas of Newfoundland, where the Gulf Stream, which comes from the south, has a higher temperature than that of the air." Like dews and rains, fogs exercise a refreshing influence on vegetation; and in some countries, like Peru, their oc-

currence is periodical and regular, and to a great extent supplies the place of rainfall, the *garuas* or sea-mists of that country being for weeks so dense as to wet the traveller to the skin. *Clouds* have been defined as "masses of visible aqueous vapour which float in the sky, or drift through it with the wind, assuming every variety of colour and form." As clouds, they exercise but an indirect effect on terrestrial climate; and it is only when they break, by further condensation, into rain, snow, and hail, that they come directly within the province of the geographer.

Meteorologists distinguish, according to form, and consequently physical characters, three *primary* sorts of clouds—the cirrus, cumulus, and stratus; and four *secondary* or transition sorts—the cirro-cumulus, cirro-stratus, cumulo-stratus, and nimbus. The *cirrus* or curl-cloud (the catstail of sailors) is composed of thin filaments, the association of which resembles curls of woolly hair, and at times a filmy texture of network. It is the highest of all clouds, resting all but motionless in the thin blue atmosphere, and is by some supposed to consist of frozen vapour or light flakes of snow. The *cumulus* or heap-cloud (the ball-of-cotton of sailors) is generally a spring or summer cloud, and presents itself in the form of rolling hemispherical masses resting on a horizontal base. Sometimes these hemispheres are built one upon the other, and form those great clouds which accumulate on the horizon, and resemble at a distance mountains covered with snow. The *stratus* or spread-cloud is a horizontal band, which forms at sunset and disappears at sunrise. Under the name of *cirro-cumulus* are designated those little rounded clouds which are often called woolly clouds; and when the sky is covered with them it is said to be *fleecy*. The *cirro-stratus* is composed of little bands of filaments, more compacted than those of the cirrus—for the sun has sometimes a difficulty in piercing them with his rays. These clouds form horizontal strata, which at the zenith seem composed of a great number of thin clouds; whilst at the horizon, where we see the vertical projection, a long and very narrow band is visible. When the cumulus clouds are heaped together, and become more dense, this species of cloud passes into the condition of *cumulo-stratus*, which often assumes at the horizon a black or bluish tint, and passes into the state of *nimbus*, or rain-cloud. The latter is distinguished by its uniform grey tint and its fringed edges; and the clouds of which it is composed are so compounded that it is impossible to distinguish them. Arranging the nomenclature in tabular order, we have, according to Luke Howard—

1. Cirrus.	}	High Ice or Snow Clouds.
2. Cirro-stratus.		
3. Cirro-cumulus.		
4. Cumulus.	}	Intermediate.
5. Cumulo-stratus.		
6. Stratus.	}	Low Rain Clouds.
7. Nimbus.		

According to M. Poëy:—

1. Cirrus.	}	Ice or Snow Clouds.
2. Cirro-stratus.		
3. Cirro-cumulus.		
4. Pallio-cirrus.		
5. Cumulus.	}	Aqueous Vapour Clouds.
6. Pallio-cumulus.		
7. Fracto-cumulus.		

Rain and Rainfall.

229. The precipitation of water from the atmosphere in the form of *rain* depends chiefly on the further condensation of clouds and fogs by the commingling of colder and warmer currents. The capacity of air for moisture decreases at a faster rate than the temperature, and thus the mingling of two currents only slightly differing in temperature may so reduce this capacity, that heavy rainfalls will take place even where there is no great decrease in atmospheric warmth. Where the temperature of the air falls below the freezing-point (32° Fahr.), the atmospheric vapour may be converted into *snow*; or if rain has been already formed in the upper air, the drops in passing through strata beneath the freezing-point will be converted into *hail*. Rain, hail, and snow are thus to a certain extent convertible phenomena,—hail occurring in all latitudes and climates, but snow only in the colder latitudes, and at elevations where the thermometer continues below 32° . Winds being the great natural agents by which the colder and warmer masses of the atmosphere are brought into combination, rains will occur most frequently where these currents are shifting and variable. Where the winds are constant and of equable temperature, rain seldom happens, unless at points where these currents impinge on lofty mountains, and carry up the air of the sea and plains into the colder regions of the atmosphere. As the capacity of the air for moisture increases with the temperature, it must happen (other things being favourable) that the amount of rainfall is greater in warm than in cold latitudes, and greater also in low-lying than in elevated districts.

230. For the foregoing reasons the amount of rainfall is greatest within the tropics, and decreases as we advance north or south into higher latitudes. It is also greater at the sea-level and moderate elevations than it is on lofty table-lands and mountains. In like manner more rain descends upon the coasts than upon the central regions of a country—the humid air from the ocean gradually parting with its moisture as it is borne farther and farther inland. In Britain, for example, where the prevalent winds are from the Atlantic, the annual rainfall on the west coast is about 37 inches, while on the east coast of the island it rarely exceeds 25 inches. It must be observed, however, that though the annual rainfall within the tropics is greater than in the higher latitudes, the number of rainy days is fewest within the tropics, or where the winds are constant, and most numerous in the higher latitudes, where the winds are shifting and variable. Thus, between 12° and 43° N. lat., the number of rainy days is stated at 78; between 43° and 46° , 103; between 46° and 50° , 134; and between 50° and 60° , as many as 161. Of course, since the rainy days are fewer in low latitudes, and the annual amount of rainfall greater, the rains must be much more powerful—a fact sufficiently recorded by all travellers in tropical regions.

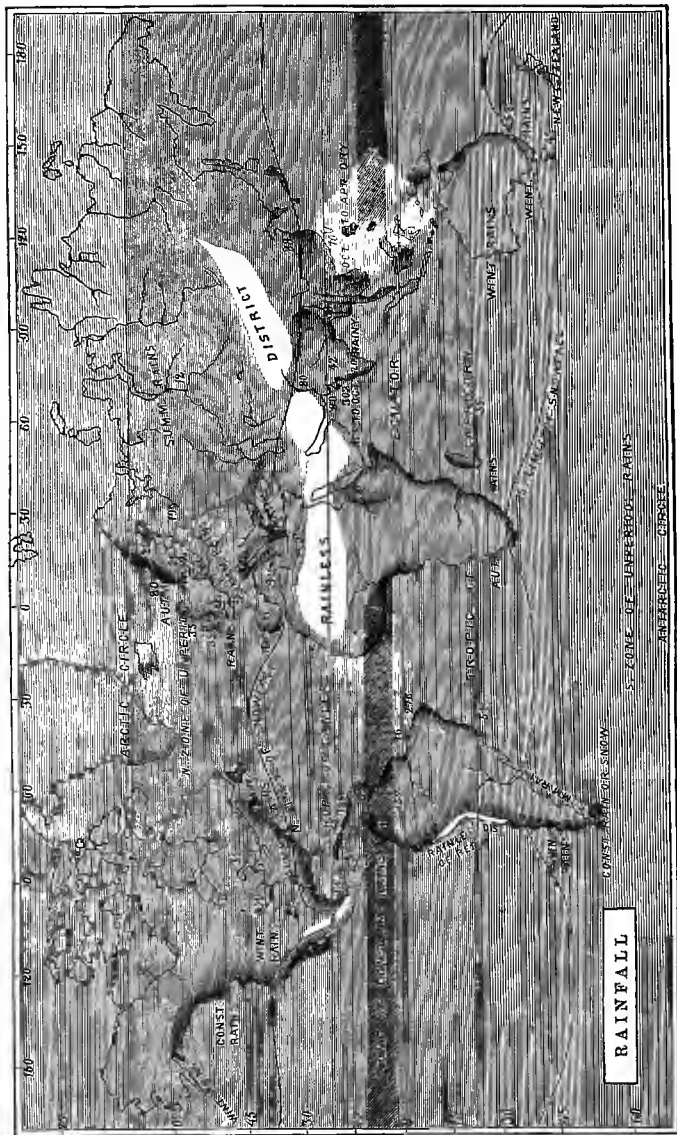
According to M. Renou, the distinguished French meteorologist, rainfall depends on the following circumstances: 1. Rain increases with the temperature, because hot air dissolves more water than cold air. 2. The moisture of the air, which attains a maximum at the sea-shore, tends to produce a maximum of rain. This cause being constant, whilst the circumstances which tend to produce rain in the atmosphere being present to the slightest extent, rain is frequent, especially small showers, and storms are rare. 3. In proportion as the mercury falls, there is more chance of rain being formed. Inversely, in countries with a high barometric pressure, such as those in the 30th degree of latitude possess, there is little prospect of rain—such regions have a tendency to become deserts. 4. Variations of temperature and irregularities of climate increase the chances of rain. 5. Finally, the form of the soil plays an important part in the production of rain. An ascending concave soil receives a maximum of rain when it is exposed to rainy winds. To these deductions it may be added that a country thickly clothed with forest-growth (other things being equal) receives a larger amount of rainfall than one destitute of wood, and presenting merely a grassy or rocky surface.

231. Understanding these principles, and bearing in mind what was stated regarding the constant, periodical, and variable winds, the student will readily perceive,—1. Why heavy and frequent

rainfalls should take place within the so-called zone of calms, where evaporation is excessive, and the air often gusty and variable ; 2. Why rain should seldom fall at sea within the region of the steady and equable trade-winds ; 3. Why the rains within the range of the monsoons should be periodical, and the year divided into two seasons, a wet and a dry ; 4. Why the rains in the higher latitudes should occur at no fixed period, but be irregularly distributed throughout the year ; 5. Why some regions, like the central deserts of Africa and Asia, and the coasts of Peru, should be altogether rainless ; and, 6. Why almost constant rains should occur in some countries, like Guiana—while in others showers of excessive violence should occasionally fall, adding to their annual rainfall as much in the space of a few hours as ordinarily happens during the course of many months.

232. As may be expected, the annual rainfall of these different regions will differ very widely ; and will be attended, of course, by proportionate results—heavy falls being beneficial in hot countries (unless they occur with such violence as to denude the surface of the soil), and moderate supplies in temperate and milder zones. In the British Islands the annual fall (as ascertained by rain-gauge) ranges from 20 to 28 inches on the eastern side, and from 40 to 80 and even 150 inches on the western side, having an average of less than 47 inches ; while in tropical countries the mean is upwards of 200 inches. As much, however, as 229 inches has been noted in Dutch Guiana, 276 in Brazil, 302 at an elevation of 4200 feet in the Western Ghauts, south of Bombay ; and in the Khasia Mountains, at the head of the river-flats or jheels of Bengal, upwards of 600 inches, or 50 feet, have been registered by several observers. At the same place, Dr Hooker has recorded 30 inches in twenty-four hours ; 21 inches have been noted at Cayenne during the same period ; and 23 inches are not uncommon near Port Jackson in New South Wales. The following are given as approximations of the annual rainfall of certain tropical districts :—Singapore, 97 inches ; Canton, 78 ; Isle of Bourbon, 166 ; Pernambuco, 106 ; Rio Janeiro, 45 ; Georgetown, 75 ; Bahamas, 56 ; and Vera Cruz, 183 ; but we still want accurate and more prolonged observation.

Referring to the excessive rainfall at Khasia, and its effects in carrying off the soil and denuding the surface, Dr Hooker, in his 'Himalayan Journal,' has the following instructive passage : " The climate of Khasia is remarkable for the excessive rainfall. Attention was first drawn to this by Mr Yule, who stated that in the month of August 1841, 264 inches fell ; and that during five successive days 30 inches fell in every twenty-four hours. Dr



** The darker tints indicate the regions of heaviest rainfall ; the figures give the annual amount in inches ; and the white spaces mark the districts which are rainless.

Thomson and I also recorded 30 inches in one day and night, and during the seven months of our stay upwards of 500 inches fell, so that the total annual fall perhaps greatly exceeded 600 inches, or 50 feet, which has been registered in succeeding years ! From April 1849 to April 1850, 502 inches fell. This unparalleled amount is attributable to the abruptness of the mountains which face the Bay of Bengal, from which they are separated by 200 miles of jheels and sunderbunds. . . . The direct effect of this deluge is to raise the little streams about Churra 14 feet in as many hours, and to inundate the whole flat, from which, however, the natural drainage is so complete, as to render a tract which in such a climate and latitude should be clothed in exuberant forest, so sterile, that no tree finds support, and there is no soil for cultivation of any kind, not even of rice. Owing, however, to the hardness of the horizontally stratified sandstone, the streams have not cut deep channels, nor have the cataracts worked far back into the cliffs. The limestone alone seems to suffer, and the turbid streams from it prove how rapidly it is becoming denuded. The great mounds of angular gravel on the Churra flat are perhaps the remains of a deposit, 50 feet thick, elsewhere washed away by these rains ; and I have remarked traces of the same over many slopes of the hills around."

233. Extending the facts alluded to in the preceding paragraphs, the rainfall of the globe may be arranged under three great heads—the periodical of the tropics, the variable of the higher latitudes, and the abnormal of certain districts where it occurs either in excess, or is altogether absent. Within the tropics the rainy season commences at the shifting of the monsoons ; and as this change is dependent upon the position of the sun, it begins earlier in those regions that lie near the equator than in those more remote. In general terms, the rainy season in the northern half of the torrid zone may be said to commence with April and last till October, while the dry season extends from October till April. In the southern half this order is reversed—the dry season embracing from April till October, and the season of rain from October till April. In Africa, for instance, near the equator, the wet season begins in April and continues till October ; while in Senegambia it does not commence till June, and then lasts till November. In India, on the Malabar coast, the rain commences early in May, but does not reach Delhi till near the end of June. In the New World, also, the rain falls at Panama early in March, but it seldom appears in California before the middle of June.

234. Commenting on the periodicity of the dry and the rainy

season within the tropics, M. Guyot makes the following lucid and graphic remarks: "Whenever the trade-wind blows with its wonted regularity, the sky preserves a constant serenity, and a deep azure blue, especially when the sun is in the opposite hemisphere; the air is dry and the atmosphere cloudless. But in proportion as the sun approaches the zenith, the trade-wind grows irregular, the sky assumes a whitish tint, it becomes overcast, clouds appear, sudden showers accompanied by fierce storms ensue. They occur more and more frequently, and turn at length into floods of rain, inundating the earth with torrents of water. The air is at this time so damp that the inhabitants are in an incessant vapour-bath. The heat is heavy and stifling, the body becomes dull and enervated: this is the period of those endemical fevers that destroy so great a number of the settlers who have come from the temperate zones. But vegetation puts on a new freshness and vigour; the desert itself becomes animated, and is overspread for a few months with enchanting verdure which furnishes pasture to thousands of animals. Nevertheless, ere long, the sun in his annual progress advances to pour down his vertical rays upon other places; the rains diminish, the atmosphere becomes once more serene, the trade-wind resumes its regularity, and the heaven shuts its windows once again until the following season. Such is the normal course of the tropical rains. They fall everywhere during the passage of the sun through the zenith. The heat is then so violent that the ascending current neutralises the horizontal trade-wind. It hurries the vapours to the heights of the atmosphere and the upper limit of the trade-wind, where they are condensed and fall back in a deluge of rain."

235. Of course, within the tropics as elsewhere, the regularity of the periodical rains is interrupted by the configuration of the land, mountain-chains, and similar causes; hence the peculiarities that mark the times as well as intensities of the wet and dry seasons of such areas as the east coast of Africa, the Red Sea, the Malabar coast, the Coromandel coast, and the coasts of Australia. On the Malabar coast, for example, the south-west monsoon (coming from the humid region of the equatorial ocean to supply the place of the highly rarefied air of the heated continent) is said to be "ushered in by terrific storms of thunder and lightning. The water pours down in torrents, and when the thunder has ceased, nothing is heard for several days but the rush of the descending rain, and the roar of the swelling streams. In a few days the storm ceases, and the earth, which before was withered by the glowing atmosphere of the dry season, is now, as if by

magic, suddenly clothed with the richest verdure ; the air above floats pure and balmy, and bright tropical clouds sail tranquilly through the sky. After this, the rains fall at intervals for the space of a month, when they again return with great violence. In July they attain their height, and from that time gradually subside until the end of September, when the season closes, as it began, in thunders and tempests." On the eastern, or Coromandel side, the order of things is reversed. The south-west monsoon, in passing over the Western Ghauts and the central table-land of the Deccan, parts with all its moisture, and reaches the eastern side as a hot, dry wind ; and it is not till the north-east monsoon begins to prevail in October that the rainy season is experienced on the coast of Coromandel.

236. Beyond the tropics the rains no longer occur at stated periods, but become *variable*—that is, are distributed throughout the year in a very irregular and uncertain manner. In some countries they occur most frequently in winter ; in some, in spring and autumn ; and in others, again, most abundantly in summer. Thus, the amount that falls in the west of England in winter is said to be eight times greater than that in summer ; in Germany the winter and summer amounts are about equal ; but in St Petersburg the winter fall is little more than a third of what descends in summer. Again, in Britain, there are more rainy days in winter than in summer ; but in Siberia it rains four times as often in summer as in winter. The countries of Europe bordering the Mediterranean are generally regions of winter rains ; while those of western Europe are distinguished rather by the abundance of their autumnal rains. In Europe north of the Alps, the north-east winds (as coming from the higher and colder latitudes) are comparatively dry ; while those from the south-west (from the humid expanse of the Atlantic) are warm and laden with moisture. On the eastern coast of North America the reverse holds good, and the north-east winds borne from the ocean give rise to the long-continued rain-storms of spring and autumn.

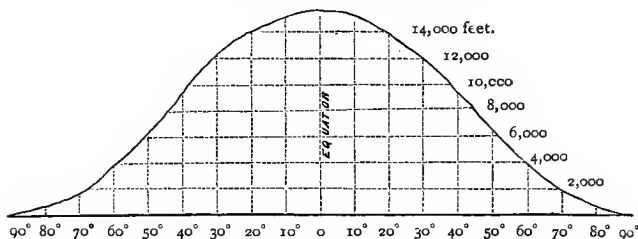
237. As might be expected, the districts of *excessive rainfall* lie within the tropics, and mainly in the immediate neighbourhood of the equator. In the New World, Brazil, Guiana, the West India Islands, Central America, and the shores of the Mexican Gulf, are all notable for their heavy and continuous rains ; while in the Old World, the coasts of Guinea and Senegambia, Eastern Africa, India, and the Indian Archipelago, are remarkable for similar phenomena. (See Rain Map, par. 229.) It must also be noted that in every latitude the rainfall becomes excessive in the neighbourhood of lofty mountains that lie in the course of

moisture-laden winds. The average fall in the south of Europe may be about 36 inches, and yet at Tolmezzo in the Alps, where the moist south-west winds from the Mediterranean are condensed, the fall amounts to 90 inches! The summits of the Apennines receive 64 inches of rain, while the lowlands around receive an average of only 26; and while the Norwegian side of the Scandinavian chain, exposed to the moisture-laden winds of the Atlantic, receives as much as 82 inches of rain, the Swedish side experiences little more than 20! Even in our own country, where the average fall is less than 40 inches in the plains, upwards of 100 inches, and some years more, have been noted in the hilly regions of Cumberland and Argyleshire. As some regions are celebrated for their rainy character, so others are equally remarkable for the entire absence of rainfall. Of these *rainless tracts* the more noted are the great desert lands of Africa, Arabia, Persia, and Mongolia—an almost continuous area, varying in breadth from the 15th to the 47th parallel, and in length from 16° west to 118° east longitude. Except on its borders this vast expanse is all but absolutely rainless, its heated atmosphere readily absorbing and converting into invisible vapour whatever humidity may be carried towards it from adjacent regions.

Snow, Glaciers, Icebergs, &c.

238. Of the other aqueous phenomena more immediately bearing on climate, the limits of a text-book will only permit the briefest allusion to hoar-frost, snow, hail, and those accumulations of frozen water known as glaciers and icebergs. *Hoar-frost* or *white-frost* is produced in the same manner as dew, and occurs chiefly in early spring and autumn, during serene nights, and when the surface of the earth falls below the freezing-point. Whatever prevents the rapid radiation of heat (overhanging foliage, passing clouds and currents), arrests the formation of hoar-frost, which is often very destructive to tender plants and to buds and blossoms in early spring. *Snow* is the frozen moisture that descends from the atmosphere when the temperature of the air at the surface of the earth is near or below the freezing-point of water. Of course, at the sea-level within the tropics, and for fifteen or twenty degrees beyond them in either hemisphere, snow is unknown; and it is only during winter that it falls in the higher latitudes, and at considerable elevations. In the polar regions, and at extreme heights in all latitudes, it becomes perennial; and this limit at which it remains unaffected by the heat

of summer is known as the *snow-line*, or, less accurately perhaps, as the line of *perpetual congelation*. The lower the latitude—that is, nearer the equator—the higher the snow-line, which descends constantly, but somewhat irregularly, according to the nature of the situation, as we proceed towards either pole. The following diagram will convey some idea of its gradual descent from 16,000 feet at the equator down to the sea-level at the poles. From the



Curve of the Snow-line according to Latitude.

equator to latitude 30° there is little variation in the height of the snow-line unless there be some peculiarity as regards winds and moisture in the situation; but from 30° to 60° the descent is very rapid, and the limit rapidly approaches the sea-level, as was formerly noted in Chap. VI., on Mountains and Mountain-Systems. As hoar-frost may be said to be frozen dew, and snow frozen mist, so *hail* may be described as frozen rain. It occurs in all latitudes and at all seasons; and though the producing causes are not always discernible, it seems mainly dependent on the meeting of aerial currents of greatly unequal temperatures, as well as on peculiar electrical conditions of the atmosphere. Falling in pellets from the size of a pea to that of a pigeon's egg, hail-storms are frequently very destructive, but luckily are always restricted to limited areas, and of short duration. *Sleet*, which is an admixture of snow and rain, or of small particles of hail and rain, generally occurs during squally weather in spring and autumn, and seems to fall from cloud-strata of different temperatures—the rain from one, and the hail or snow from another.

239. As snow must accumulate on all mountain-ridges above the snow-line, as well as on the surface of all polar lands within the limits of perpetually frozen ground, it will become more or less compressed, and this compression will be greatly augmented by its partial meltings in summer, as also by the falling and freezing of rain and other atmospheric vapours. From this ac-

cumulation, compression, and re-freezing, arise avalanches, glaciers, icebergs, and other kindred phenomena. *Avalanches* (Fr.) are accumulations of snow, or of snow and ice, which are frequently precipitated with destructive violence from lofty mountain-ridges, like those of the Alps, into the valleys and plains below. They originate on the higher slopes, and begin to descend when the weight of their mass becomes too great for the declivity on which it rests, or when rainy weather destroys its adhesion to the surface. *Glaciers*, on the other hand, are accumulations of ice, or of ice and snow, which collect in the valleys and ravines of snowy mountains, like the Alps and Himalayas, or on boreal uplands like those of Greenland, and which move downwards with a peculiar creeping motion, smoothing the rocks over which they pass, and leaving mounds of debris (*moraines*), lateral and terminal, as they melt away. In mountain-gorges, glaciers descend as ice-streams till, coming below the snow-line, they begin to melt and disappear; but on polar lands, where they cover almost the entire surface, they move downwards to the sea-shore, and there, losing their support, the advancing fronts break off and are floated away as *icebergs* (ice-mountains) and ice-floes (ice-islands). The true mountain-glacier and lowland ice-mantle, though kindred phenomena,



Junction of Glaciers exhibiting lines of medial Moraines.

differ widely in their results—the former merely smoothing and grinding a course for itself in the mountain-gorge, the latter smoothing and rounding and striating the whole rock-surface of the country, and as it moves downward to the shore discharging its broken fringe of iceberg and debris forward into the ocean. Such ice-masses have been met in the Arctic and Antarctic Oceans several miles in circumference, rising from 40 to 200 feet above the water, and loaded with stones and shingle. Some idea of

their size may be formed from the fact that little more than a ninth of their bulk rises above the water, the specific gravity of ice being only 0.9. As they are floated by the polar currents to warmer latitudes they melt away, dropping their burden of boulders and debris on the bottom of the ocean. "Fields" and "packs" of such ice are familiar phenomena both in arctic and antarctic waters—the bergs of the north being seldom carried southward in the Atlantic beyond the 44th parallel of latitude, while those of the south are not unfrequently found northward as far as the Cape of Good Hope, or, on an average, at 10 degrees lower latitude.

240. As climatological agents, snow and ice have considerable influence on the regions in which they occur. Accumulating on mountain heights, they are the perennial sources of the springs and streams that descend to refresh and fertilise the thirsty lowlands; while in tropical countries the winds that pass over them are cooled, and flow downwards to temper the sultry atmosphere of the plains below. Masses of floating ice are productive of similar results, the seas and coasts in their vicinity being cooled by their presence, and fogs and rain-storms generated as they melt away. In the higher latitudes, on the other hand, where the winters are severe, snow forms a warm covering for the soil (the *snow-blanket*, as it is termed by farmers), and greatly defends vegetation from the rigour of the frost. Composed of crystals, it entangles among its interstices a large amount of air, which is a bad conductor of heat, and thus it at once prevents the escape of heat from the earth, and sets a limit to the depth to which severe frosts can penetrate. Within the polar circle, also, the darkness of the long winter is considerably diminished by the *snow-sheen* or *snow-blink*—snow reflecting, instead of absorbing like the bare ground, the faint light that there proceeds from the sky.

Causes affecting Climate.

241. In its technical sense, the term *climate* (Gr. *klima*, an inclination) denotes an imaginary belt of the globe parallel to the equator, and so called by the earlier geographers, because the differences of these climes depend on the inclination or obliquity of the sphere. Between the equator and the polar circle there were twenty-four such climatic belts—each depending on the increasing length of the day (half an hour's increase for each belt), and of course contracting in breadth from the equator towards the poles. From the polar circles to the poles there were six climes

—the differences of the longest day in their case being counted by monthly periods instead of half-hours. The term is now employed in a much wider sense, as embracing the entire *weather-conditions* of any district, and as such we shall now proceed to consider its relations. Although the climate of a locality is mainly dependent on its heat and moisture, yet so many circumstances tend to disturb and modify these conditions, that the subject becomes extremely complicated and difficult of determination. Latitude, height above the sea, distance from the ocean, nature of soil, distribution of land and water, direction of mountain-chains, winds and rains, currents of the ocean, cultivation, and the like, all exert their influence in modifying the weather-conditions or climate of any special locality.

242. As repeatedly stated, the main element in climate is the amount of heat received by the sun, and this diminishes (par. 204) according to the latitude or distance from the equator. Owing, however, to the obliquity of the earth's orbit, the regularity of this decrease is alternately interrupted in either hemisphere, and the respective length of day and night at opposite seasons becomes an important element in climatic diversity. Within the tropics day and night are all but equal—the longest day being little more than thirteen hours, and the shortest nearly eleven. In the latitude of Greenwich the longest day is nearly seventeen hours, and the shortest only seven; while within the polar circles there is a brief summer period when the sun never sets, and a corresponding winter season when he never rises. Bearing these facts in mind, it will be readily understood why the year within the tropics is divided into two seasons—a wet and a dry. The latter is regarded as the summer, and the former as the winter; but they are in direct opposition to the astronomical seasons, as the rains (par. 233) follow the sun. In some inter-tropical countries, as the West Indies, there are two rainy seasons and two dry seasons within the year. In the temperate zone, again, the year is divided into four seasons—spring, summer, autumn, and winter; but this regular succession of climatic change can hardly be considered as extending farther than from the 35th to the 60th parallels. In the frigid zones, on the other hand, only two seasons are known—a long and severe winter, during a portion of which the sun never rises above the horizon, and a brief but fervid summer, when that luminary never sets. From these circumstances it will be at once perceived that the torrid zone is the region of greatest heat throughout the year, with comparatively little difference between its seasons; that the temperate zones stand next in order as regards the annual amount

received, but experience great difference of temperature during the successive seasons ; and that the frigid zones are regions of small annual heat, and at the same time subjected to seasonal extremes. Such is the general climatic order as regards latitude ; though, owing to the smaller extent of land, the decrease of heat, as we depart from the equator, is more rapid in the southern than in the northern hemisphere—so that, on a general average, the latter is about $3\frac{1}{2}^{\circ}$ warmer than the former.

243. Altitude is the next great modifier of climate, but owing to many correlative circumstances (prevalent winds, slope, proximity to the sea, &c.), its operation is not altogether uniform. As formerly stated, a decrease of 1° Fahr. takes place in the lower regions of the atmosphere for every 300 or 350 feet of ascent ; but at great heights and in extreme latitudes the decrease is more rapid. As it is, under every latitude the loftier mountains (Himalayas, Alps, Andes, &c.) are perpetually covered with snow ; the higher plateaux (Mexico, Bolivia, Armenia, Tibet, &c.) are several degrees colder than the contiguous lowlands ; and in temperate zones such table-lands experience much greater extremes of summer's heat and winter's cold than the surrounding districts—having, like Spain, Armenia, and Persia, summers of tropical heat and winters of almost polar severity. Another great cause of modification is the unequal specific heat of the land and water (par. 206), by which islands and sea-coasts are rendered cooler in summer and warmer in winter than inland tracts—creating what has been termed *insular* and *continental climates*. Britain, New Zealand, and Tasmania enjoy, in this respect, insular climates ; Germany, central Russia, and Tartary, continental ones. Connected with this, and depending on the set of the trade-winds and ocean-currents, may be noticed the observation of Humboldt, that the continents and larger islands in the northern hemisphere are warmer on their western than on their eastern sides ; while in the southern hemisphere the reverse holds good—the western being the colder and the eastern the warmer.

244. It would exceed the limits of a text-book to describe in detail the many causes concerned in the modification of climates ; but besides those of latitude, altitude, and proximity to the sea, may be noticed the following :—

1. The direction of mountain-chains, which, by intercepting cold winds, renders the countries on one side warmer than those on the other ; and in like manner, by intercepting moist winds, favours the production of rain on the windward slopes and droughts on the leeward or sheltered declivities. The eastern slopes of the Andes, for example, intercept the humid trade-winds

from the Atlantic ; their counter-slopes on the Pacific side are arid and rainless.

2. The general inclination or slope of a district, as this may lie to the heat of the morning and noonday sun, or be turned to the feebler rays of his afternoon and evening declension.

3. Owing to their different specific heat, the relative masses and configuration of the land and water greatly affect the climatic peculiarities of a country ; for as moist and warm winds generally come from the sea, while cold and dry ones blow from the land, the seaboard has a moist and cloudy sky that prevents radiation, while the interior has a serene sky that favours it and lowers the temperature,—and radiation is greater in summer than in winter, and consequently interferes with the amount of heat directly received from the sun.

4. The prevailing winds of a region, as these may be cold or warm, dry or humid. The westerly winds of our own island are humid and warm—the easterly are cold and dry ; hence the greater rainfall and mildness of our western coasts as compared with the eastern.

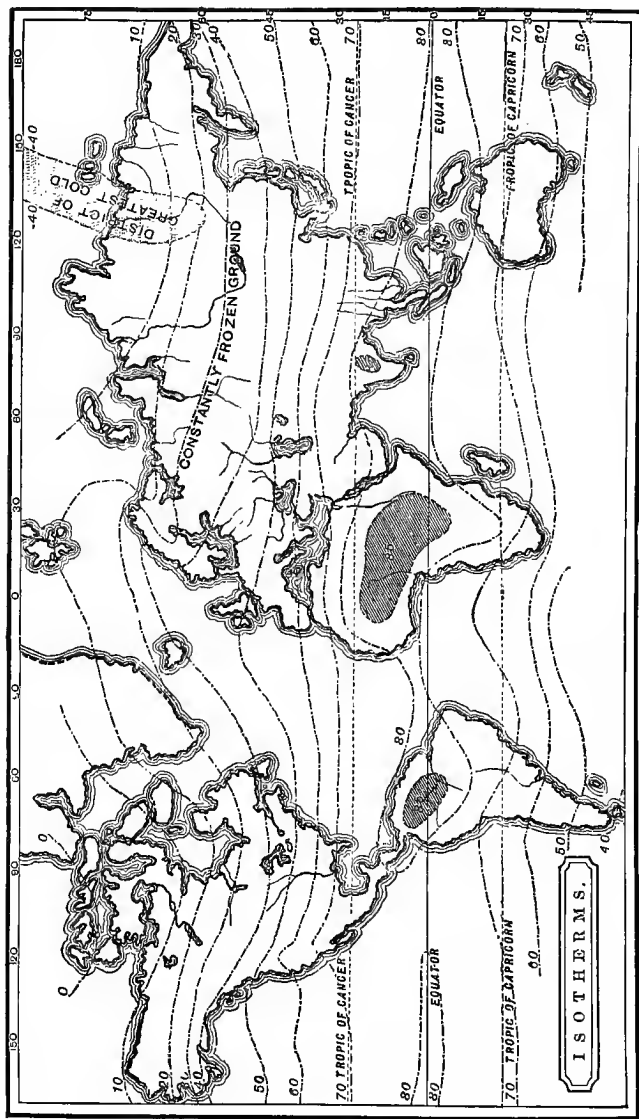
5. As with winds, so in like manner with the influence of oceanic currents. The Gulf Stream, by bringing warmth and moisture, mitigates the winter climate of western Europe ; the Arctic current, on the other hand, tempers the summer climate of the eastern shores of North America.

6. The direction of river-plains and valleys, as they open out to favourable winds and ocean-currents. The westerly reception of the Rhine basin produces a finer climate than the easterly trend of the Danube, even though the latter be several degrees farther south ; and the southerly slope of the valley of the Rhone enjoys amenities unknown in the westwardly-trending basins of the Loire and Garonne.

7. Cultivation has also a marked effect on the climate of a country—the felling of forests, draining of lakes and morasses, and the like, being all favourable to greater dryness, warmth, and general amenity.

Lines of Equal Heat, &c.

245. Under circumstances mentioned in the preceding paragraphs, it will readily be perceived that the belts of climate can by no means correspond with the parallels of latitude, but that it requires a long series of observations to determine the *seasonal temperatures* of summer and winter, and also a careful average of these to ascertain the *mean yearly temperature* of any given



locality. If the surface of the globe had been all water, or all land of equal altitude, the parallels of latitude would have determined the lines of climate; but this not being the case, the daily temperature, the summer and winter temperatures, as well as the mean annual temperature of any two places in the same latitude, may differ very considerably. In this way the maximum summer heat of an island may be several degrees below that of a continental country between the same parallels, while its winter temperature is many degrees higher. In this way, also, the mean annual temperature of some island or sea-coast may be equal to that of some inland district situated several degrees nearer the equator. A series of lines drawn through places having the same summer temperature show these variations at a glance, and are termed *isothēral lines* (Gr. *isos*, equal, and *theros*, summer), or lines of equal summer heat; those through places having the same winter temperature, *isocheimōnal lines* (Gr. *isos*, and *cheimon*, *cheimonos*, winter); and those connecting places of the same mean annual temperature, *isothermal lines* (Gr. *isos*, and *therme*, heat). The difference between the summer and winter temperatures may amount to 2°, 20°, 40°, or more degrees of Fahrenheit; but the isothermal lines show the mean amount of heat received throughout the year, and, of course, are the more correct indicators of the general climatic conditions of any given locality. In the accompanying Sketch-Map the isotherms are laid down for every ten degrees, and their bendings northward and southward (according to distribution of land and water, altitude, distance from sea, influence of ocean-currents, &c.) convey to the eye instructive proofs of the operating causes adverted to in the foregoing paragraphs.

In amplification of the preceding remarks on Climatology, the following passage from Mrs Somerville may be read by the student with advantage: "Places having the same mean annual temperature often differ materially in climate. In some the winters are mild and the summers cool, whereas in others the extremes of heat and cold prevail. England is an example of the first; Quebec, St Petersburg, and the arctic regions are instances of the second. The solar heat penetrates more abundantly and deeper into the sea than into the land; in winter it preserves a considerable portion of that which it receives in summer, and from its saltness does not freeze so soon as fresh water; hence the ocean is not liable to the same changes of temperature as the land, and by imparting its heat to the winds it diminishes the severity of the climate on the coasts and in islands, which are never subject to such extremes of temperature as are experienced in the interior of

continents. The difference between the influence of sea and land is strikingly exemplified in the high latitudes of the two hemispheres. In consequence of the unbounded extent of the ocean in the south, the air is so mild and moist that a rich vegetation covers the ground, while in the corresponding latitudes in the north the country is barren from the excess of land towards the Polar Ocean, which renders the air dry and cold. A superabundance of land in the equatorial regions, on the contrary, raises the temperature, while the sea tempers it.

“Professor Dove has shown from a comparison of observations that northern and central Asia have what may be termed a true continental climate both in summer and in winter—that is to say, a hot summer and cold winter; that Europe has a true insular or sea climate in both seasons, the summers being cool and the winters mild; and that in North America the climate is inclined to be continental in winter and insular in summer. The extremes of temperature in the year are greater in central Asia than in North America, and greater in North America than in Europe, and that difference increases everywhere with the latitude. In Guiana, within the tropics, the difference between the hottest and coldest months in the year is only $2^{\circ}.2$ Fahr., in the temperate zone it is about 60° , and at Yakutsk, in Siberia, $114^{\circ}.4$. Even in places which have the same latitude, as in northern Asia compared with others in Europe or North America, the difference is very great. At Quebec the summers are as warm as those in Paris, and grapes sometimes ripen in the open air, yet the winters are as severe as those in St Petersburg. In short, lines drawn on a map through places having the same mean summer or winter temperature are neither parallel to one another, nor to the isothermal or geothermal lines, and they differ still more from the parallels of latitude.”

NOTE, RECAPITULATORY AND EXPLANATORY.

In the two preceding chapters attention has been directed to the Climatology of the globe—that is, to those weather-conditions on which its vegetable and animal life are so intimately dependent. The main medium of climate being the Atmosphere, it was necessary to advert to its nature and composition as an integral portion of our planet. As an aerial fluid, it consists of an admixture of 79 parts nitrogen and 21 oxygen, together with a small

but variable proportion of carbonic acid gas, traces of ammonia, &c., and always holding in suspension less or more of aqueous vapour in a visible or invisible form. Constituted as plants and animals are, this composition is indispensable to their existence—the former decomposing carbonic acid and setting free the oxygen, the latter, in counterbalance, emitting carbonic acid gas and absorbing oxygen. Light and invisible as this aerial envelope may appear, it exerts a pressure on the earth's surface, at the sea-level, of about $14\frac{3}{4}$ lb. avoirdupois to the square inch—a pressure which is balanced by a column of mercury 30 inches in height; hence the *barometric column* of the meteorologist, and the *rise and fall of the barometer* according to changes in the weight of the atmosphere. As an elastic or compressible medium, its lower strata are denser or heavier than those at great elevations; and as its capacity for heat and moisture decreases with its rarity or attenuation, the higher regions of the air are colder and drier than those at a lower elevation.

As the medium through which the light and heat of the sun are conveyed to the terraqueous surface, the atmosphere—partly owing to the varying inclination of the sun's rays, but mainly owing to the fundamental differences in the mode of reception and radiation of heat by land and water—becomes variously heated in its different regions, and hence arise winds or aerial currents,—the warm air of one locality expanding and ascending, and the colder rushing in from all sides to supply the deficiency. The winds thus generated assume various directions and physical characteristics—the chief cause of modification being the different amounts of heat received by the different zones of the earth. Thus some are said to be *constant*, as the trade-winds of the tropics; others *periodical*, as the monsoons and the sea and land breezes; and others, again, *variable* and irregular, as the winds of the higher latitudes. In their physical characters they are governed chiefly by locality and the nature of the region from which they blow, and are thus hot or cold, moist or dry, relaxing or invigorating—floating as a zephyr that scarcely disturbs the thistle-down, or sweeping as hurricanes that uproot forests and overturn buildings.

The warmer the air, the greater its capacity for moisture; but in every case there is a point beyond which it is incapable of sustaining more vapour in an invisible form. It is then said to be *saturated*; and in this state any cooling, by coming in contact with the colder earth, or by the contact and commingling of colder aerial currents, produces condensation into dews, fogs, rains, snow, hail, and other kindred phenomena. These aqueous

phenomena,—whether descending as *dew*, from the unequal temperatures of the earth and air—as *fogs* and *mists*, from unequal temperatures of aerial strata—or as *rains*, by more sudden condensation,—are all essential to the vegetable and animal economies. Rains, like the winds on which they mainly depend, are almost constant within certain equatorial districts ; periodical within the regions of the monsoons ; and irregular in all the higher latitudes. Some tracts—as the Sahara, Egypt, Arabia, Persia, Mongolia, and Peru—are rainless, or all but rainless ; but in most countries the rainfall, though varying from month to month and year to year, is, in the long average, tolerably regular and persistent. It will vary, of course, according to latitude, direction of prevailing winds, proximity to the ocean, direction of mountain-chains, and the like ; hence its great difference, even on opposite sides of the same island,—annual falls within temperate zones varying from 10 to 80 inches, and within tropical, from 100 to 500 or 600 inches. When the temperature of the air falls below the freezing-point, fogs and mists are converted into snow, and rain into hail—*snow* being mainly an extra-tropical and winter precipitation, *hail* occurring in all latitudes and at all seasons of the year. Within the tropics at the level of the sea snow is unknown ; in temperate zones it falls less or more during winter ; but in polar regions, and at great elevations above the sea in all latitudes, its presence is perennial. The altitude at which snow remains unaffected by the heat of summer (the *snow-line*) varies with the latitude—descending from 14,000 or 16,000 feet at the equator to near the sea-level at either pole. The latitudinal limit, north and south (the *snow-limit*), varies also according to the distribution of sea and land—receding and advancing as either element prevails. The perpetual presence of snow and ice on lofty mountain-ridges and polar uplands gives rise to *avalanches*, *glaciers*, and *icebergs*—phenomena whose geological influences are not less apparent than their climatological effects.

The causes which affect the *climate* or weather-conditions of any locality are thus extremely varied—latitude, altitude, distribution of land and water, proximity to the sea, influence of cold and warm ocean-currents, prevalent winds, direction of mountain-chains, slope, nature of soil, cultivation, and the like, all more or less exerting their modifying influences. Heat and moisture, however, are the great regulators of climate ; and thus, in general terms, climatological zones may be said to decrease in importance from the equator to the poles. Nevertheless, this decrease by no means coincides with the parallels of latitude ; hence, to deter-

mine the mean temperature of any locality, numerous thermometrical observations have to be made at hourly, daily, monthly, and yearly intervals. The results of such observations enable the meteorologist to connect places having the same summer, winter, and mean annual temperatures ; and hence the scheme of exhibiting them at a glance by means of *isothermal*, *isocheimonal* or *isocheimal*, *isothermal*, and other lines.

To the student who would enter more fully into the consideration of the atmosphere and its phenomena, and especially into the subject of climatology as affecting the plant-life and animal-life of the globe, we would recommend perusal of some treatise on meteorology, as the essay by Sir John Herschel ; Dr Thomson's 'Elements ;' or Buchan's 'Handy-book of Meteorology.'

XIII.

LIFE—ITS DISTRIBUTION AND FUNCTION.

Life as affected by External Conditions.

246. HAVING noticed the general relations of the Land, Water, and Atmosphere, and the principal phenomena arising therefrom, we now turn to the Life by which they are respectively peopled. Hitherto we have dealt with the *inorganic* phases of nature; we have now to consider the *organic*. In the former case, the study involved consideration merely of *chemical and mechanical forces* acting from without; now we have to deal with the superaddition of *vital action* operating through peculiar organs from within. The material aspects and relations of nature form the themes of the physicist; the vital or organic constitute the study of the physiologist. Under the term *Life* is embraced all that appertains to the vegetable and animal kingdoms,—subjects which belong to the domain of Botany and Zoology, and only come under the notice of Geography in so far as they are dependent on external conditions for their position or distribution on the globe. The origin, nature, and function of Life form the theme of Biology (Gr. *bios*, life); its distribution and external relations become important considerations in the study of Physical Geography; and the interdependence of Plants and Animals—their food, locality, specific change, and other vital phenomena—constitute some of the most interesting and subtle problems of Philosophy.

247. Whatever be the nature and origin of Life, it is clearly dependent for its continuance on the physical conditions by which it is surrounded. A little more heat or a little more cold, a little more moisture or a little more drought, and the plant flourishes or decays, the animal increases or dies. It is obvious, then, that, on a globe having different zones of climate, having regions of

excessive humidity and regions of excessive drought—and having, moreover, different areas of land and water—life must be as diversified in its nature as the conditions under which it is destined to exist. The arrangement of plants into aquatic, terrestrial, and aerial—into flowering and flowerless—into trees, shrubs, herbs, grasses, mosses, lichens, sea-weeds, &c.—belongs to the province of Botany ; and of animals into aquatic, terrestrial, and amphibious—into mammals, birds, reptiles, fishes, shell-fish, &c.—belongs in like manner to the province of Zoology. What the geographer has more especially to consider is their distribution over certain areas, the physical conditions apparently concerned in their restriction to these areas, and the dependence of the one kingdom upon the other, as completing the economy of nature. As it is Life that gives to creation its highest interest, so the consideration of its relations becomes the highest theme of our subject. For the sake of brevity, the term *flora* (Lat.) is employed to designate the plant-life of a region or epoch, and the term *fauna* its animal-life ; hence we speak of the “Flora of South America” and the “Fauna of South America”—the Flora of the littoral zone and the Fauna of the deeper sea-bed. This is the distribution of plant-life or animal-life in space ; its occurrence in one or more of the geological systems constitutes its distribution in time.

248. So far as the eye, or the eye aided by the microscope, can perceive, life is everywhere present—in the air, on the earth, and in the water, or even parasitic on and within other plants and animals. Unless, perhaps, among the perpetual snows and ices of the poles and lofty mountain-peaks, its manifestations are sufficiently apparent ; and even in these situations some forms unknown to observation may find a permanent or temporary home. And yet, universal as life may appear, it is confined to the merest film of the terraqueous globe. A few thousand feet above the sea-level on land, and a few thousand feet beneath it in the waters, limit this *stratum of life* on either hand. Thickest at the equator, it thins out towards the poles ; and densest near the sea-level, it becomes rarer and rarer the more it rises above or falls beneath this line of greatest intensity. Air, heat, light, moisture, nature of soil, and food, are the great regulators of life on the land ; or heat, light, depth, nature of bottom, saline composition, and food, the main regulators in the ocean. Were it not for these causes there is no reason why the same forms of life should not prevail in every region from the equator to the poles, and from the shore-line to the darkest abysses of the ocean. The influence, however, of external conditions is insuperable. The palm of the tropics would

dwarf and die in the temperate zone ; the whale of the Greenland seas would perish in the waters of the equator ; the rush that luxuriates in the marsh would wither if transferred to the arid upland ; the shell-fish that swarm within the influence of the tides would die if submerged to the depth of a few hundred fathoms ; the fresh water that forms the vital element for one family becomes the poison of another that has been destined to inhabit the saline waters of the ocean. The correlations of life to its material surroundings, and of plants and animals to one another, is one of the most curious, as it is one of the subtlest, problems in biological philosophy.

249. Every plant and every animal is adapted by nature to the position it occupies, and within that position it continues to fulfil its functions so long as the surrounding conditions remain unchanged. Why one genus or kind should differ from another genus, man may never know ; and, at all events, the inquiry belongs to the subject of biology, and not to that of physical geography. Again, why certain forms should only appear in certain regions—the kangaroo, for instance, in Australia, the ostrich in Africa, and the llama in South America—while other regions seem equally fitted for their residence, is a question involving considerations of origin, and of geological alternations of land and water, that lie beyond the scope of our subject. What more immediately concerns geography, are the existing distribution of plants and animals, the conditions accompanying that distribution, and the question how far they are capable of being transferred to, and *acclimatised* in, other districts for the luxury and necessities of man. These are the subjects of importance to the merchant, trader, and farmer—the determination of the regions of supply, the amount and quality of products, and the possibility of the profitable growth and cultivation of the plants or animals in other countries than those which they naturally occupy.

250. Some tribes have naturally a wider range than others ; some, again, have a more elastic constitution, and are capable of enduring greater diversities of climate ; and others, obeying the instincts of food, procreation, &c., migrate from the unfavourable season of one region to the favourable season of another, and from the fresh-water river to the salt-water sea,—returning at stated times to repeat the migration. Of all animals man has the widest range,—his superior intelligence enabling him to modify and overcome conditions that would be fatal to other creatures. Many, however, of the domesticated animals and cultivated plants have also considerable elasticity of constitution, and thus man has been

enabled to carry them along with him over the greater part of the habitable globe. In this way we require to distinguish between the truly *indigenous* or native products of a country, and the *exotic* or imported, though many species have been so long transferred and retransferred that it is now impossible to point to their original habitats. While, therefore, there is a natural apportioning of plants and animals to certain areas, and while external conditions are evidently the main regulators of this distribution, it must ever be borne in mind that man has already modified, and is continually modifying, this distribution, by transferring, cultivating, and destroying, according as his wants and wishes may compel. His operations, however, can never extend beyond a mere modification; for over and above his control remain the great conditions of heat, light, moisture, &c., which ever govern the main geographical arrangements of plants and animals; and it is to these alone that the limits of a text-book will permit us to refer.

Plant-Life—its Distribution and Governing Conditions.

251. As already mentioned, heat, light, moisture, and soil are the principal conditions affecting the terrestrial distribution of vegetable life. These conditions have their greatest intensity near the equator; hence the greatest exuberance of vegetation within the tropics, and its gradual declension as we proceed towards either pole. As might be anticipated, however, this declension is governed more by the isotherms than by the parallels of latitude—the *mean* amount of annual heat being the predominant condition in vegetable distribution, though the amount of summer heat (isothermal) has also much to do with its ripening and perfection. The mean annual temperature of two places may be the same, and yet the summer temperature of the one may be 10° higher than that of the other, while the winter temperature may be 15° or even 20° lower. Much, therefore, in Botanical Geography depends upon the amount of heat which a plant receives during the period of its greatest activity, and this, again, is regulated more by the monthly than by the annual isotherms. A few months of high summer heat, even where the winter cold is intense, are much more favourable to the maturation of certain fruits and grains than a milder climate where the summer and winter temperatures are less decided. The zones of vegetation shading more gradually into each other than the astronomical zones (torrid, temperate, and frigid), botanists make a minuter

subdivision of the earth's surface into equatorial, tropical, sub-tropical, warmer-temperate, colder-temperate, sub-arctic, arctic, and polar—each characterised by some peculiar feature, though partaking on either side of the forms that belong to the two adjacent zones.

Latitudinal Distribution.

252. The *equatorial* zone, bounded by the isotherm of 79° , is characterised, wherever moisture is present, by its luxuriant vegetation. It embraces the central regions of Africa from shore to shore, Ceylon, the southern portion of the Indian peninsula, Malaya, the Indian Archipelago, the northernmost parts of Australia, New Guinea, and other Pacific islands in the same latitudes, a large portion of equatorial South America, including Columbia, Peru, Guiana, and the northern parts of Brazil. Succulent stems, large and showy flowers, gigantic parasites and climbers, arborescent grasses (canes, bamboos, &c.), orchids, palms, bananas, bread-fruits, custard-apples, silk-cottons, banians, and the like, are typical of this belt, the greater portion of which, for reasons given in the preceding chapter, lies to the north of the equator.

253. The *tropical* zones, extending to the isotherms of $73\frac{1}{2}^{\circ}$ on either side of the equator, include, in the New World, Bolivia, Brazil, and Paraguay in the southern hemisphere, and the West Indies, Yucatan, Guatemala, and part of Mexico in the northern; while in the Old World they embrace Nubia, Senegambia, Madagascar, Mauritius, and North Australia in the southern hemisphere, and South Arabia, India, Burmah, and Southern China in the northern. These zones are characterised by palms, bananas, pine-apples, tree-ferns, species of fig, pepper-shrubs, cinnamon, indigo, cotton, coffee, sugar-cane, &c.—there being fewer parasites, and more underwood in the forests than in the equatorial zone. And as palms and bananas may be said to mark the equatorial zone, so may arborescent ferns and species of fig be said to predominate in the tropical.

254. The *sub-tropical* zones, bounded by the isotherm of 63° , embrace Southern Africa and Australia, Paraguay, La Plata, and Chili in the southern hemisphere; and North Africa, Egypt, Syria, North Arabia, Persia, Northern India, part of China, the Southern States of North America, Mexico, and California in the northern hemisphere. They are characterised by a luxuriant growth of magnolias, laurels, myrtles, and figs, together with certain palms,

zalias, cactuses, and arborescent euphorbias. In these zones, as in the damp regions of the preceding belts, vegetation is green throughout the year, and the climate, unless where rainless, is described as delightful. They are pre-eminently the lands of the laurel and myrtle.

255. The *warmer-temperate* zones, limited by $53\frac{1}{2}^{\circ}$, are still regions of evergreens, but are marked by the absence of palms—the dwarf palm of Europe, the palmetto of North America, and the Chilian palm, being, as it were, outlying forms from the sub-tropical zone. Deciduous forest-trees, oaks, chestnuts, &c., and figs, oranges, pomegranates, olives, and the vine, are typical of the warmer-temperate in the northern hemisphere; shrubby ferns, arborescent grasses, and araucariæ in the southern. This “region of evergreen trees,” as it has been called, embraces the well-known flora of southern Europe, as well as those of Asia Minor, the north of China, and Japan.

256. The *colder-temperate* zone, bounded by the mean annual temperature or isotherm of $42\frac{1}{2}^{\circ}$, is, in the northern hemisphere, the great zone of deciduous forest-trees, or those which shed their leaves in winter—hence the seasonal contrasts unknown in warmer regions. The characteristic vegetation of this zone is well seen in that of our own country, the north of France, and Germany—forests of coniferous trees (fir, pine, yew, &c.), and expanses of heath adding peculiar features to the area. The cultivation of wheat scarcely extends beyond this zone in the northern hemisphere; in the southern it is occupied chiefly by the ocean—Tierra del Fuego, Falkland Islands, and Kerguelen’s Land being the only important portions.

257. The *sub-arctic* zone, limited by the isotherm of 39° , is characterised by coniferous trees (pine, larch, spruce, juniper, &c.), poplar, beech, grasses, and heaths; and on its northern limits, by birch, willow, and alder, which become dwarfed, and never attain to the size of trees. “This zone,” says Professor Balfour, “is of less extent than the preceding, and in the interior of Asia it is perhaps not so easily distinguishable from it as in Europe. In the northern hemisphere it is the zone of firs and willows; in the southern it embraces a few barren islands. The northern parts of Siberia and Norway, the Farøe Islands, and Iceland belong to this zone. In the Farøe Islands barley does not always ripen, but the turnip and potato generally succeed. The Amentiferæ (plants bearing catkins) in these as well as in Iceland do not become trees. Grasses, common heath, and juniper, form features in the physiognomy of Iceland; in Siberia, forests of pine, larch, spruce, poplar, and birch occur.”

258. The *arctic* zone (which has no equivalent in the southern hemisphere, where the ocean alone prevails) is marked by the dwarf birch, alder, and willow ; by occasional pines and firs ; by grasses ; and by numerous lichens and mosses on its northern limits. At Hammerfest, in lat. 71° , according to the authority just quoted, potatoes, turnips, cabbage, and carrots generally succeed. In the American section, rhododendron, andromeda, and azalea are not unfrequent.

259. The *polar* zone is characterised chiefly by its flowerless plants—lichens and mosses—though, during its brief summer, dwarfed species of ranunculus, saxifrage, scurvy-grass, rush, willow, &c., make their appearance. In this zone there are no trees nor bushes, nor any cultivation of plants for food. In the cold zones it has been remarked that there are more genera and fewer species, and that while the species are few the individuals are numerous.

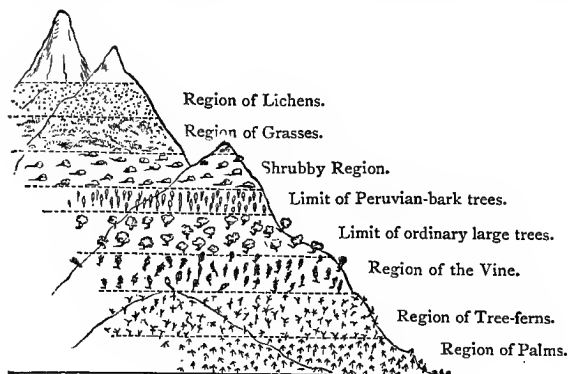
Altitudinal Distribution.

260. Such, in general terms, is the characteristic distribution of vegetable life as we proceed from warmer to colder latitudes. But the student is already familiar with the fact that temperature decreases not only as we proceed from the equator towards the poles, but also as we ascend from the level of the sea into the higher regions of the atmosphere. This ascent—*hypsommetrical*, as it is technically termed (Gr. *hypsos*, height, and *metron*, measure)—is marked by analogous belts of vegetation ; and at the equator, for instance, the traveller who ascends a lofty mountain passes through a flora much akin to that which marks the successive horizontal zones alluded to in the preceding paragraphs. "We pass," says Herschel, "through the same series of climates, so far as temperature is concerned, which we should do by travelling from the same station to the polar regions of the globe ; and in a country where very great differences of level exist, we find every variety of climate arranged in zones according to the altitude (*hypsommetrical* zones), and characterised by the vegetable productions appropriated to their habitual temperature." Thus Humboldt, in describing the South American Alpine flora, remarks : "In the burning plains scarce raised above the level of the Southern Ocean, we find bauanas, cycads, and palms in the greatest luxuriance ; after them, shaded by the lofty sides of the valleys in the Andes, tree-ferus ; and next in succession, bedewed by cool, misty clouds, cinchonas (Peruvian-bark trees) appear.

When lofty trees cease, we come to aralias (ivies) and myrtle-leaved andromedas (heaths); these are succeeded by bejarias, abounding in resin, and forming a purple belt around the mountains. In the stony region of the Paramos, the more lofty plants and showy flowering herbs disappear, and are succeeded by large meadows covered with grasses, on which the llama feeds. We now reach the bare trachytic rocks, on which the lowest tribes of plants flourish. Paramelias, lecidias, and leprarias (lichens), with their many-coloured thalli and fructification, form the flora of this inhospitable zone. Patches of recently-fallen snow now begin to cover the last efforts of vegetable life, and then the line of eternal snow begins."

261. In the Old World similar phenomena present themselves; and out of numerous examples we may take the following account of the Himalayan vegetation, as observed by Madden and Strachey in their journey from the plains of India, through Kemaon, to Tibet: "Ascending, we find forms of temperate climates gradually introduced above 3000 feet, as seen in species of pine, rose, bramble, oak, berry, primrose, &c. At 5000 feet the arboreous vegetation of the plains is altogether superseded by such trees as oak, rhododendron, andromeda, cypress, and pine. The first ridge crossed ascends to a height of 8700 feet in a distance of not more than ten or twelve miles from the termination of the plains. The European character of the vegetation is here thoroughly established; and although specific identities are comparatively rare, the representative forms are most abundant. From 7000 to 11,000 feet—the region of the Alpine forest—the trees most common are oak, horse-chestnut, elm, maple, pine, yew, hazel (growing to a large tree) and many others. At about 11,500 feet the forest ends—Webb's pine and the Bhojatran birch being usually the last trees. Shrubs continue in abundance for about 1000 feet more; and about 12,000 feet the vegetation becomes almost entirely herbaceous. On the southern face of the mountains the snow-line is probably at an elevation of 15,500 feet. The highest dicotyledonous plant noticed was at about 17,500 feet, probably a species of echinospermum. A nettle, also, is common at these heights. The snow-line here recedes to 18,500 or 19,000 feet. In Tibet itself the vegetation is scanty in the extreme, consisting chiefly of caragana, species of artemisia, potentilla, and a few grasses. The cultivation of barley extends to 14,000 feet. Turnips and radishes on rare occasions, are cultivated at nearly 16,000 feet. Vegetation ends at 17,500 feet—scanty pasturage being found only in favoured localities at this elevation; and the highest flowering-plants are corydalis, cruciferæ, sedum, and a few others."

262. In temperate latitudes, though the variety of vegetation be less, and the lower zones of tropical flora be necessarily wanting, similar phenomena present themselves. "We may begin the ascent of the Alps, for instance, in the midst of warm vineyards, and pass through a succession of oaks, sweet chestnuts, and beeches, till we gain the elevation of the more hardy pines and stunted birches, and tread on pastures fringed by borders of perpetual snow. At the height of 1950 feet the vine disappears; and at 1000 feet higher the sweet chestnuts cease to thrive; 1000 feet farther, and the oak is unable to maintain itself; the birch ceases to grow at an elevation of 4680 feet; and the spruce fir at the height of 5900 feet, beyond which no tree appears. The rhododendron then covers immense tracts to the height of 7800 feet; and the herbaceous willow creeps 200 or 300 feet higher, accompanied by a few saxifrages, gentians, and grasses; while lichens and mosses struggle up to the imperishable barrier of eternal snow." On the Pyrenees, in like manner, the following belts have been observed: 1. The zone of vine and maize cultivation, and of the chestnut woods. 2. A zone extending from the limit of the vine to about 4200 feet, at which limit the cultivation of rye ceases; here we meet with box, saxifrage, gum, &c. 3. From the limit of the cultivation of esculent vegetables at 4200 feet to the zone of the spruce-fir. 4. From the limit of the spruce-fir



Hypsometrical Zones of Vegetation.

zone, at 6000 to 7200 feet, characterised by the presence of the Scotch fir. 5. From 7200 to 8400 feet is an Alpine zone, characterised by the dwarf juniper, *Saxifraga bryoides*, *Soldanella alpina*, *Juncus trifidus*, &c. 6. A zone above 8400 feet exhibits a few

Alpine species, as *Ranunculus glacialis*, *Draba nivalis*, *Stellaria cerastoides*, *Androsace alpina*, and *Saxifraga Gröenlandica*. The accompanying sketch exhibits, in general terms, the order of these ascending zones of vegetation, from the sea-level at the equator to the limit of perpetual snow.

Local Distributions.

263. Besides the great governing conditions of temperature, as dependent on latitude and altitude, there are others arising from light, slope, nature of soil, moisture, &c., which, though less general, are nevertheless equally imperative. The southern slopes of a mountain-range, exposed to the full influence of the sun's rays, exhibit not only a greater profusion of foliage and blossom, but a greater variety of species than is to be found on the northern and darker side. Even the southern side of a tree will make a larger amount of annual growth, and present a greater exuberance of flower and fruit, than the northern; and so unfailing is the continuity of nature that this effect of insulation is as well marked on the fossil trunks of the Carboniferous and Jurassic epochs as on the concentric layers of the modern flora. And yet, though heat and light are so indispensable in the economy of vegetable life, influencing their luxuriance, colours, and secretions, it must be remembered that while some families require full exposure to these influences, others luxuriate only in the shade. Nor must it be forgotten, as already noticed under Climatology, that the *quality* of the sun's rays is affected alike by altitude and the nature of the atmosphere (clear, or dense and foggy) through which they pass; and hence the difference of their influence on plants and animals. "The chemical rays of the spectrum," says Sir J. Herschel, "are powerfully absorbed in passing through the atmosphere, and the effect of their greater abundance aloft is shown in the superior brilliancy of colour in the flowers of Alpine regions." As to the effects of density, or pressure at great heights, it is questionable whether it is at all appreciable—the diminished temperature at such altitudes being the main cause of change in the plant-life of such situations.

264. Again, the influence of soil is equally observable: hence we seek in vain on the clayey moorland for the species that form the rich and verdant carpeting of the calcareous district; or on the thirsty sand-dunes by the sea-shore for the flora that flourishes so freely on the alluvial meadow. This influence arises, of course, partly from the mere mechanical nature or texture of the soil

and its capabilities of retaining heat and moisture, and partly also from chemical composition—the plant deriving therefrom certain ingredients which are necessary to the healthful growth and elaboration of its tissues and secretions. Every geologist has noted the difference of vegetation on the different rock-formations of a country, each belt of limestone or clay, of granite or trap-rock, being characterised by a predominance and luxuriance of certain species; and the skilled farmer talks of hop-soils, bean-soils, wheat-soils, and turnip-soils—certain peculiarities of soil being most favourable to certain peculiarities of husbandry and rotation. Further, some plants are truly littoral, and flourish only (like the mangrove and cocoa-palm) within the influence of the sea-spray; while others become stunted and diseased if exposed, even for a season, to the breath of the sea-breeze.

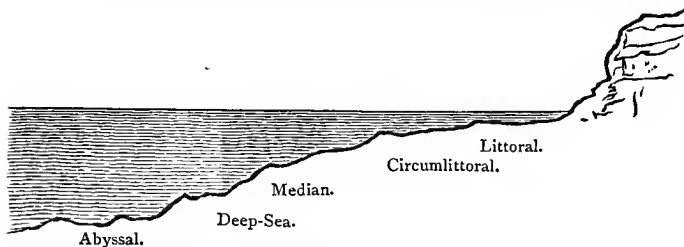
265. The effect of moisture on the distribution of vegetation is direct and perceptible, arid tracts being comparatively barren, while humid regions, and especially humid and warm ones, are noted for their luxuriance. Even in tropical countries, like South America, the dry season is one of torpidity, and corresponds to the winter of temperate zones—vegetation being dormant till the rainy season returns and once more renews its growth and foliage. It is owing to this influence of moisture that botanists distinguish between rainy and rainless regions, and between zones of summer rains, winter rains, and rains at all seasons,—each zone being stamped by its own vegetable aspects. But beyond this common influence of moisture on all vegetable forms, there is a natural adaptation of certain forms to moist situations; and for this reason we have plants—some inhabiting the sea, others lakes and rivers, and some, again, the marsh and mudflat.

Oceanic Distribution—Horizontal and Bathymetrical.

266. As plants have a fixed and natural distribution on land, so also they have a similar distribution, horizontal and vertical, in the waters; though, in consequence of the greater uniformity of temperature, the marine areas are less marked and decided. *Horizontally*, the ocean has been divided into certain botanical provinces of which our limits will merely permit the enumeration: 1. The Northern Ocean, from the pole to the 60th parallel; 2. The North Atlantic, between the 60th and 40th parallels—the great headquarters of *Fucus* proper; 3. The Mediterranean—a sub-region of the warmer-temperate zone of the Atlantic, lying

between the 40th and 23d parallels ; 4. The tropical Atlantic, in which *Sargassum* abounds (Sargasso Sea, par. 139) ; 5. The Antarctic American regions, from Chili to Cape Horn, and the whole circumpolar ocean south of 50° of S. latitude ; 6. The Australian and New Zealand ; 7. The Indian Ocean and Red Sea ; 8. The Japan and China Seas, besides certain less decided provinces in the Pacific.

267. *Vertically*, or *bathymetrically*, as it is termed when treating of the ocean (Gr. *bathys*, deep ; *metron*, a measure), heat, light, and nature of sea-bed seem to be the prime regulators of aquatic



Bathymetrical Zones.

vegetation. In the limited areas of streams and fresh-water lakes the order of arrangement is less perceptible, but in the ocean each gradually-deepening zone is characterised by its own peculiar forms. Thus, in the British seas naturalists speak of a littoral, laminarian, coralline, and coral zone ; and in the ocean generally, of a littoral, circumlittoral, median, infra-median, deep-sea, and abyssal zone. The nature of these bathymetrical subdivisions will be best understood by referring to our own shores, where the *littoral* is that which lies between high and low water mark, and is characterised by such plants as the bladder-wrack, dulse, and cariceen ; the *laminarian*, that which commences at low-water mark, and extends to a depth of from 40 to 60 feet, and marked, as its name implies, by the broad waving tangle (*laminaria*), the larger algæ, and the beautiful scarlet sea-weeds (*florideæ*) ; the *coralline*, that which extends from 90 to about 300 feet in depth, and where corallines (millipores, sertularians, flustræ) luxuriate, and the common sea-weeds disappear ; and the *coral zone*, which lies between 300 and 600 feet, and is the region of the calcareous and stronger corals. In the abysses of the ocean diatoms (microscopic vegetable forms) alone occur ; and generally as the coral-lines increase the true sea-weeds disappear, ordinary algæ scarcely existing beyond a depth of 300 feet.

Plant Distribution—Regions, &c.

268. Admitting, however, in the fullest degree, the influence of heat, light, moisture, and the like, in the distribution of vegetable life, there still lies over and above them a primal arrangement, by which certain forms are naturally restricted to certain areas. This arrangement, which is seemingly not dependent on climate (for the plants thrive equally well when transferred to other areas), imparts a certain physiognomy to these regions; and thus botanists, entering more minutely into the geographical aspects of their science, subdivide the earth into *regions* and *provinces* according to their prevalent floras. Such subdivisions lie beyond the limits of our outline, but the learner will readily perceive their bearings when he considers—*first*, that some forms, like the tea-plant and camellia, are peculiar to eastern Asia; some, like the eucalypti and casuarinæ, to Australia; others, like the magnolia, to the southern latitudes of North America, and so on: while, *second*, that every tribe of plants has a special aspect or physiognomy, and where such tribes prevail, that physiognomy will be imparted to the landscape. Wherever, therefore, certain orders are peculiar, and a certain number of genera and species prevail, this constitutes a botanical “region,” such as the region of saxifrages and mosses, the region of magnolias, the region of camellias and teas, region of palms, and so on—making in all some twenty-four regions, into which the earth’s surface has been botanically divided. In like manner with aspect or “physiognomy,” as the Palm form, the Banana form, the Mimosa form, Cactus form, Heath form, Grassy form, Willow form, &c.—there being in all twenty-two such forms, which are readily distinguished even by the eye of the unbotanical observer.

Having regard to the geographical distribution of the various forms of plants upon the earth’s surface, Dr Bentham has proposed to arrange existing plants into three main geographical groups—viz., the “Northern Flora,” the “Southern Flora,” and the “Tropical Flora.” The *Northern Flora* includes three geographical types or sub-floras—the Arctic-alpine, the Temperate, and the Mediterranean; the *Southern Flora* is divided into Antarctic-alpine, Australian, Andine, Mexican, and South African; while the *Tropical Flora* is made up of the three sub-floras proper to Indo-Malaya, Mid-Africa, and South America. (See also par. 276.)

Agricultural Zones.

269. In the same way it is not unusual to divide the Old and New Worlds into *agricultural* zones, in something like the following order, from the tropics to the northern limit of profitable culture: 1. Zone of rice and maize; 2. Maize and Wheat; 3. Wheat, rye, buckwheat, peas, and beans; 4. Barley, oats, and potato. Commenting on the agricultural zones, Professor Balfour remarks, that in the Old World, "*the zone of barley, oats, and the potato*, includes Finmark and the higher districts of Scandinavia, the Farøe Islands, and the most northerly part of Scotland and Ireland—the north boundary being 62° , 70° , and 67° , and the south boundary 57° in Scotland, 52° in Ireland, 65° , and 60° . That the *zone of rye and wheat* occupies the greater part of Europe north of the Alps, and extends to about 50° latitude, or as far as the polar limit of the cultivation of the vine; and that in this zone buckwheat, peas, and beans, are also important articles of food. That the *zone of wheat* includes those parts of Europe and western Asia which lie south of the 50th degree; and that in several districts maize is cultivated as well as wheat. That the *zone of rice and wheat* embraces those provinces which are subject to the influence of tropical seasons—in tropical western Africa rice and maize being the chief grains. This zone extends from about 15° N. lat. to about 28° S. lat." In the New World, Berghaus distinguishes the following zones: 1. Rye, wheat, and barley (summer cereals); 2. Rye and maize; 3. Wheat and maize; 4. In the tropical zone maize is the principal cereal grown.

Commercial Zones.

270. *Economically* or *commercially*, it has also been attempted to arrange the earth's surface into four great vegetable zones—the tropical, southern temperate, northern temperate, and arctic—each, no doubt, shading into the other, but still, on the whole, broadly made up of its own peculiar products:—

The *first*, for example, is characterised by and yields such produce as dates, bananas, cocoa-nuts, tamarinds, guavas; yams, melons, cassava, sago, maize, rice; sugar, coffee, cinnamon, cloves, nutmegs, pepper, ginger; vegetable butter, vegetable ivory, gutta-percha, caoutchouc; aromatic gums, vanilla, opium, betel; cotton, indigo, dye-woods, sandal-wood, mahogany, teak, &c. The *second*

is characterised by the date, orange, lemon, fig, pomegranate, olive, vine ; rice, maize, millet, wheat, barley ; the potato ; tea, Paraguay tea ; cotton in the northern part, and flax and tobacco throughout ; walnut, chestnut, cork, mimosa, birch, &c. The *third* by the apple, pear, cherry, plum, gooseberry, currant, strawberry, cranberry ; wheat, barley, oats, buckwheat ; tobacco, hops, flax, hemp ; beet, turnip, cabbage ; oak, ash, beech, birch, maple, lime, elm, alder, pine, larch, &c. And the *fourth* by the gooseberry, currant, strawberry, cranberry ; Iceland and reindeer moss ; Scotch fir, larch, birch, alder, willow, and juniper.

271. Such, in general terms, is the distribution of plants over the surface of the globe. Though many families have a very narrow range, and naturally are never found beyond it, yet others having greater facilities for the dispersion of their seeds, and being, moreover, of a more elastic constitution, have a tendency to increase their area, and this often at the expense of other families that are destroyed by their presence—nature exercising, as it were, a power of selection, by which some races are extinguished and others brought prominently forward to predominate for a period, and then to give way in turn to new and advancing species. Others, again, possessing this greater adaptability, are transferred by man for their utility or ornament from region to region, and are now found *acclimatised* and growing luxuriantly in many countries to which they naturally would never have found their way. In general, however, the great natural laws of distribution are supreme, and the majority of plants attain their perfection only in the habitats to which they originally belong. In densely-peopled and cultivated countries man is ever destroying, transferring, and acclimatising ; but, knowing the limit to which this power can be profitably exercised, he will cease to rear in one region what can be more abundantly and cheaply procured from another. It is thus that a knowledge of the geographical distribution of plants, and the laws on which that distribution depends, becomes a subject not only of scientific interest, but of true economic importance.

XIV.

LIFE—ITS DISTRIBUTION AND FUNCTION.

Animal Life—its Distribution and Governing Conditions.

272. BEING influenced by climate, food, and other external conditions, animals, like plants, are necessarily less or more restricted to certain geographical regions. Endowed with greater powers of dispersion and locomotion, their limits are, perhaps, less precise than those of plants ; but in the main there is a similar horizontal and vertical arrangement of animal forms—from the equator to the poles, and from the sea-level to the loftiest heights of land, or to the greatest depths of ocean. The *fauna* of the tropics, taken in general terms, is more exuberant in kind, in size, strength, and beauty, than that of the temperate zones ; and this, again, more abundant than that of the arctic and antarctic regions. The more luxuriant and sheltered lowlands are peopled by races differing from those that inhabit the mountain-slopes, and those that affect the mountain-sides are distinct from those that find subsistence among the higher and colder elevations. In like manner, the creatures that throng the shallow shore are specifically different from those that are scattered through the deeper ocean. These belts (horizontal and vertical) of similar life are known as *homiozoic zones* (Gr. *homioios*, similar ; *zoe*, life), and though not so sharply defined as the regions of vegetation, are still of utility in the arrangements and descriptions of the zoologist. In the great *stratum of life* every plant and animal has its own natural horizon, and in that horizon it takes some particular spot better fitted for its growth and development than another—and this spot in the case of a plant is known as its *station*, and in the case of an animal as its *habitat*.

Latitudinal Distribution.

273. In this way terrestrial animals may be broadly arranged into a tropical, a temperate, and an arctic fauna—each shading to a certain extent into the other, but still, in the main, characterised by genera and species that do not naturally occur in the other sections. Thus, the Tropics are the great headquarters of the apes and monkeys; of the lion, tiger, panther, hyena, and larger carnivora; of the giraffe and zebra; the elephant, rhinoceros, hippopotamus, and tapir; the crocodile, turtle, boa, and larger reptiles; the ostrich, flamingo, peacock, parrot, humming-bird, and generally of birds remarkable for their brilliant and variegated plumage. Insect-life is also much more varied and exuberant in tropical than in colder latitudes—attaining its maximum in variety, in size, activity, and brilliancy of hue, within the luxuriant regions of Brazil, Guinea, and the Indian Archipelago, and gradually declining towards either temperate zone. This declension does not take place, of course, everywhere in the same ratio, for wherever there is abundance of plant-life, there certain insects increase in corresponding numbers; and variety in plant-life is also attended by a greater variety of insect-life—each genus, and often each species, being limited to its own peculiar vegetation.

274. The Temperate zones, on the other hand, though marked on their warmer limits by the presence of such tropical forms as the tiger, jackal, hyena, crocodile, &c., are, on the whole, the headquarters of such ruminants as the ox, bison, buffalo, goat, sheep, stag, and elk. The useful animals—that is, those more especially fitted for domestication, like the horse, ox, sheep, dog, &c.—increase in the milder zones, while the larger carnivora decrease not only in species, but in power and numbers. Peculiar to them also are the Bactrian camel, the wild boar, wolf, fox, and beaver; the opossum in the northern hemisphere and the kangaroo in the southern; the eagle and falcon, turkey, goose, grouse, and pheasant, among birds; while reptiles become fewer and smaller the nearer we approach the arctic zone. Insects also, with the exception of beetles, decrease in species, size, and brilliancy—the beetles being specifically more abundant in temperate than in tropical climes, though inferior in size and brilliancy of colouring.

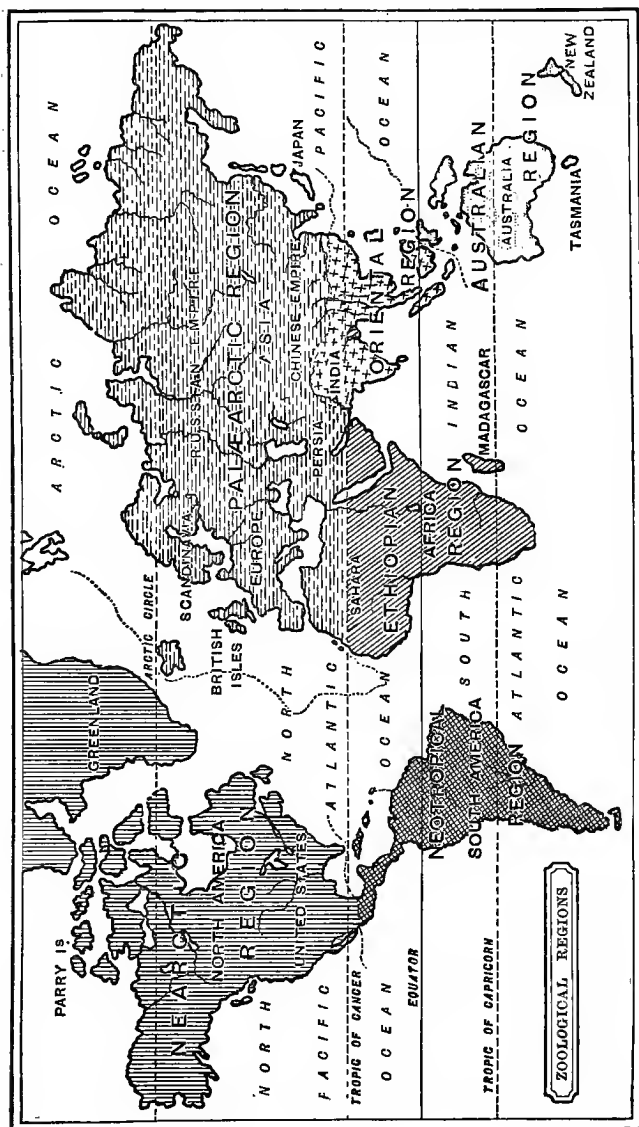
275. The Arctic zone (for the Antarctic is almost exclusively occupied by the ocean) is characterised by greater uniformity in its fauna, by few species but by numerous individuals, and generally by the quiet and sombre colouring both of its birds and quadrupeds. The reindeer, musk-ox, brown bear, polar bear,

wolf, arctic fox, and sable, are peculiar to this region ; the sea-fowl that frequent its summer seas are chiefly migrants from the waters of the colder-temperate zone ; and reptile-life is unknown. And here it may be observed, that as the land in the northern hemisphere lies in great contiguous or all but contiguous masses, while in the southern it consists of far-separated spurs and patches, so there is a greater similarity between the fauna and flora of northern than of southern zones. The Life of the Antarctic zones occurs in dissimilar and far-scattered specks and patches, while in the Arctic, the musk-ox, reindeer, polar bear, Esquimaux dog, and arctic fox occur in uninterrupted continuity wherever they can find a habitable locality.

Localisation and Representation of Species.

276. It must ever be borne in mind, however, that although external conditions have most distinctly a paramount influence in regulating the range of living beings, there is, over and above, an aboriginal dispersion the origin of which is one of the most difficult problems for which science has yet to furnish a satisfactory solution. Why, for example, should the kangaroo be restricted to Australia, and the hippopotamus and giraffe to Africa ; the camel to the Old World, and the llama to the New ? Why, on the other hand, do we find distant regions, having nearly the same climatic conditions, peopled—not by forms precisely identical, as might have been expected—but by representative species ; that is, by species zoologically distinct but representing each other in the economy of nature and fulfilling corresponding functions ? Thus the lion and tiger of the Old World are represented by the puma and jaguar of the New ; the ostrich of Africa by the rhea of South America and the emu of Australia ; the crocodile of the Nile by the gaviol of the Ganges and the alligator of the Amazon. Nor are these strange phenomena peculiar to the groups of living beings which now inhabit these different areas ; but they were to the full as strikingly characteristic of their predecessors,—the sub-fossil faunas of Asia, America, and Australia differing from each other in the same direction and to the same extent, and showing precisely the same strange correspondences as do their faunas of the present day. How far these peculiarities in the animal populations of widely separated areas are dependent upon the inevitable changes brought about in the lapse of ages by the ever-varying distribution of sea and land, is not yet fully determined. But natural causes such as these must have greatly

affected the wellbeing of the species composing these faunas, by disturbing their local conditions of food and shelter, by destroying their relative immunity from enemies, and the like ; and must have thus brought about the rapid dispersion of some species, and caused others to lose their ground, or diminish in numbers, or even, finally, to disappear altogether. Relying upon these facts, naturalists have found it possible of late years to parcel out the land surface of the globe into six Zoological Regions, each peopled by a fauna largely peculiar to itself, but possessing a certain proportion of species in common with its neighbours. These regions, which have only subordinate relations to climate, shade into each other along their lines of contact, as do the zones already described, and, like these, present peculiarities of vegetable life almost as important in degree as those of the animal world. These regions, first indicated by Mr Sclater, and recently more exactly defined by Mr Wallace, our greatest authority in Geographical Zoology, possess the following characteristics: (1.) *The Palearctic or Northern Old World Region* includes the whole of Europe, all temperate Asia lying north of the latitude of the southern slopes of the Himalaya mountains, and Africa north of the Great Desert. This region is marked by the prevalence of such animals as bears, deer, horses, rabbits, and wild goats ; eagles, hawks, jays, and sparrows ; and to its limits are confined almost all the known species of goats and sheep, of moles and dormice, the majority of the robins, magpies, and finches, and the whole of the group of the pheasants. (2.) *The Ethiopian or African Region* embraces the whole of Africa south of the Tropic of Cancer, the large island of Madagascar and its dependencies, and the southern portion of Arabia. Its fauna is marked by the absence of northern forms, as the bear, deer, ox, and camel, and by the presence of a wonderful collection of large and peculiar quadrupeds found nowhere else—the gorilla, the chimpanzee, the baboon, the lion, the rhinoceros, the hippopotamus, and the giraffe ; together with such remarkable birds as the ostrich, the guinea-fowl, and the ibis and flamingo. (3.) *The Oriental or Indian Region* comprises, generally speaking, the countries of Hindostan and Further India, and the East Indian islands, &c., as far as the Strait of Macassar. In this region only do we find the orang-outang, the tiger, the honey-bear, the civet, the flying lemurs, and the flying squirrels ; the magnificent peacock, the argus pheasant, the laughing-thrushes, and the curious little tailor-birds. (4.) *The Australian Region* includes Australia, New Zealand, Polynesia, and those Malayan islands lying east of the Strait of Macassar. This region is pre-eminently distinguished by the absence of the higher mam-



malia of other areas, their position being occupied by marsupial or pouched animals, such as the kangaroo proper, the wombat, the tree-kangaroo, and the kangaroo-rat. The bird-life, however, is abundant and varied, and is rich in handsome and peculiar forms, such as the beautiful birds of paradise, the crimson lories, the lyre-birds, and the strange-looking emus and cassowaries.

(5.) *The Nearctic or North American Region* comprises the whole of the continent and islands of North America lying to the north of the Tropic of Cancer. Although agreeing almost exactly with the Palæarctic region as regards temperature, it differs from it most materially in the composition of its fauna, having none of the hedgehogs, dormice, pigs, or sheep of the Old World; but showing instead such peculiar animals as the skunk, the racoon, the opossum, and the prairie-dog. The thrushes, wrens, and finches of Europe are represented by new families of birds; while the mocking-birds, the blue jays, and a host of others, are wholly peculiar, as also are the rattlesnakes and most of the lizards.

(6.) *The Neotropical or South American Region* includes all America and the neighbouring islands lying south of the Tropic of Cancer. This is altogether the most remarkable of all the great zoological divisions of the earth, both as regards its deficiencies in the animal types found in other areas, and in the marvellous abundance and variety of the forms peculiar to itself. The Old World tropical genera of the elephant, rhinoceros, and antelope are here replaced by a large array of genera known nowhere else, such as the sloth, the armadillo, the ant-eater, the llama, the alpaca, chinchilla, &c.; the bloodsucking vampire-bat, and the prehensile-tailed monkeys. The bird-life is equally prolific and varied, as seen in the peculiar toucans, the todies, the macaws, the curassows, and above four hundred species of humming-birds. These geographical regions answer equally well for the *Vegetable* world. We find each to be characterised by an assemblage of plants peculiarly its own. The region formed by the temperate areas of the *Old World* is the natural home of the larch, the beech, the ash, the oak, the elm, the walnut, and the chestnut among trees; and of the apple and pear, the cranberry, the strawberry, the currant, and the orange among fruits. The *African* region south of the Sahara nourishes the enormous baobab, the oil-palm, and the tamarind; and, farther south, crowds of beautiful flowering heaths, aloes, and pelargoniums. The *Indian* region is the natural habitat of the ginger-plant, rice, mango, bamboo, cinnamon, and ebony. In the *Australian* region alone do we meet with the peculiar gum-trees, grass-trees, marsh oaks, and bread-fruit trees. In the central darts of the *North American* region flourish the hemlock, the

Douglas pine, and the gigantic Wellingtonia ; and, near its southern limits, the sugar-cane, cotton-plant, maize, and tobacco. Finally, the richly prolific *South American* region claims as its own the brilliantly flowering cactuses and passion-flowers, the medicinal cinchona, the useful india-rubber and logwood trees, and the ornamental rosewood and mahogany.

Marine Distribution—Homoiozoic Zones.

277. As with the terrestrial fauna, so also in a great measure with the marine, though at first sight there may seem no interruption to interchange and community of habitat. Variety of genera and species characterises the seas of the torrid zone ; uniformity of species and immense numbers of individuals mark the fauna of the colder latitudes. The fishes and shell-fish of the tropics are noted for their varied and brilliant tints ; those of the arctic regions are of uniform and sombre hues. The right whale is never found beyond the cold waters of the higher latitudes in either hemisphere ; the sperm whale, on the other hand, is unknown beyond the tropical areas of the Pacific. Unknown in the torrid zone, the seal and walrus occur in thousands in the colder-temperate and arctic regions. The headquarters of the sharks lie within the torrid zone ; the tunny rejoices in the genial waters of the Mediterranean ; while the cod, haddock, pilchard, herring, and salmon—the great majority of the food-fishes, in fine—attain perfection only within the colder waters of the higher latitudes. The constituents of the sea-water are nearly the same everywhere, and yet the reef-building corals elaborate their structures only within the tropical and sub-tropical expanses of the ocean.

278. For the sake of greater precision, it has been attempted to subdivide these broad divisions into narrower belts called “homoiozoic zones,” or zones of similar life—these belts encircling the ocean and corresponding to a great extent with the climatic belts of the terrestrial surface. In the northern hemisphere these “homoiozoics” are the median, the circumcentral, the neutral, the circumpolar, and polar, and are thus defined by their originator, the late Professor Edward Forbes :—

1. The *Median* zone is that of the equator and the tropics, the most important part of which comprises the whole of the Indian Ocean and the central belt of the Pacific, from the coasts of Australia, Borneo, and Japan, to those of Mexico and Columbia. In this region, for the most part, marine animals present the most brilliant colours and varied forms. This, too, is the region where

the waters swarm with the greatest number of organisms, and corals and madrepores construct their circular islands, which stud the coasts of Asia as far as the middle of the Southern Ocean. Between equatorial Africa and America this homoiozoic zone is still continued in spite of the interposition of two continents: on the coasts of Florida, the Bermudas, the Antilles, the Guianas, and Brazil, molluscs, echinoderms, and corals, similar to those of other equatorial seas, multiply abundantly: the species are different, but the general types are the same.

2. To the north of the median zone, which extends round the globe with an average breadth of 3700 miles, there is another encircling zone—the *Circumcentral*—which is much narrower, and rendered very irregular by the variations of climate, which, towards the north, are produced by winds, marine currents, and the different conditions of the opposite continental coasts. This zone originates in the Atlantic, on the coasts of Georgia and the Carolinas, then spreading out towards the east, its waters wash the coasts of Morocco and of the Spanish peninsula. Beyond the Straits of Gibraltar it embraces the Mediterranean, where there are fisheries for the tunny, sponge, and red coral. In this sea the species show a gradual diminution from west to east; and in the enclosed basins of the interior of the continent—the Black Sea, the Caspian, and the Sea of Aral—they are even much less numerous. In the Pacific, this same zone (the limits of which are, however, very indefinite) stretches from the coasts of the Corea and Japan towards those of California.

3. The third zone—the *Neutral*—is situated about the middle of the temperate latitudes of the northern seas. Like the last-mentioned zone, its boundaries curve and spread out across the Atlantic from the coasts of America to those of Europe. It is narrow along the shores of Virginia and Delaware, but it widens towards the north-east with the Gulf Stream, and embraces all the Celtic seas of the peninsula of Brittany, Ireland, Scotland, and the Shetland Isles. The Baltic Sea and its gulfs are mere dependents on this zone. The great herring-fisheries are carried on in this homoiozoic region.

4. The most northerly zone, which is characterised by fisheries for cod and other fish of a similar nature—the *Circumpolar*—likewise follows the immense curve of the Gulf Stream, and stretches from east to west. Beginning at Cape Cod in the Bay of Fundy, it embraces Iceland and the adjacent seas, and washes the coasts of Norway and Lapland up to the North Cape. In the Pacific the waters of this zone assume, like those of the neutral zone, a circular tendency, owing to the great current of Japan and

the north-west winds, which in this part of the ocean bring about a circuitous movement similar to that of the Gulf Stream.

5. The Arctic seas are occupied by the *Polar* homoiozoic zone, the extent of which comprises the whole of the area stretching from the Pole to Labrador, the Gulf of Obi, Behring Strait, and Kamtchatka. In this region the inhabitants of the sea, generally speaking, are of rather dull colours, and the species are much less numerous than in the southern zones; but, on the other hand, these species are for the most part represented by a greater number of individuals.

In the southern hemisphere, the homoiozoic zones follow one another in the same order as in the northern, and exhibit similar conditions between the respective typical species; but as yet the comparative extent of the southern belts is very imperfectly known and defined.

Vertical or Bathymetrical Distribution.

279. As with the horizontal areas of the water, so in like manner with its various depths or bathymetrical zones. The *littoral zone* (par. 267) of our own seas, for example, is characterised, according as the bottom may be rocky, sandy, or muddy, by such shell-fish as the periwinkle, limpet, mussel, cockle, and razor-shell; the *laminarian* by star-fishes, the common sea-urchin, tubularia, modiola, trochus, and pullastra; the *coralline* by the disappearance of the ordinary shore-shells, and the abundance of buccinum, fusus, oyster, venus, pecten, and the like; and the *coral zone* by forms of star-fish, cidaris, and brachiopod mollusca that cannot exist in shallower waters. The extreme depths of the ocean—that is, from 1000 to 3000 fathoms—which were formerly regarded as utterly barren of life, have recently been shown, by deep-sea soundings and dredgings, to be the abode of a fairly abundant though lowly fauna—foraminifera, diatoms, polycystines, sponges, corals, crinoids, star-fishes, and crustacea, having being brought up at these depths, more especially in the warmer areas of the North Atlantic. There is no depth limit to animal life in the ocean. All the invertebrate classes of animals found in shallower water occur also at extreme depths, and even some special groups of fishes. But it appears probable that they decrease in number and variety, as well as in size, in the *abyssal* areas. As a general rule, their distribution appears to be affected mainly by conditions of temperature. The abyssal region of the ocean extends generally from a depth of 500 or 600 fathoms to

the bottom ; and the temperature of its waters is, as a rule, below 40° Fahr. This region is peopled by a fauna characterised by the abundance and variety of certain special invertebrate groups, and is remarkably uniform all over the world. Its more striking forms are highly ornamented rhizopods (*Challengeridæ*), hexactinellid sponges, crinoids, star-fishes, sea-urchins, and a remarkable group of crustacea. Low temperature and absence of light do not seem to be specially inimical to these forms ; while their tissues, being of the same density with the surrounding medium, are not materially affected by the pressure at these depths.

“The conditions of pressure,” says Sir Wyville Thomson in his ‘*Depths of the Sea*,’ “are certainly very extraordinary. At 2000 fathoms a man would bear upon his shoulders a weight equal to twenty locomotive engines, each with a long train loaded with pig-iron. We are apt to forget, however, that water is almost incompressible, and that therefore the density of sea-water at a depth of 2000 fathoms is scarcely appreciably increased. At the depth of a mile, under the pressure of about 150 atmospheres, sea-water, according to the formula given by Jamin, is compressed by the $\frac{1}{14}$ of its volume ; and at twenty miles, supposing the law of compressibility to continue the same, by only $\frac{1}{7}$ of its volume—that is to say, the volume at that depth would be $\frac{6}{7}$ of the volume of the same weight of water at the surface. Any free air suspended in the water or contained in any compressible tissue of an animal at 2000 fathoms would be reduced to a mere fraction of its bulk, but an organism supported through all its tissues on all sides, within and without, by incompressible fluids at the same pressure, would not necessarily be incommoded by it. We are already familiar, chiefly through the researches of the late Professor Sars, with a long list of animals of all the invertebrate groups living at a depth of 300 to 400 fathoms, and consequently subjected to a pressure of 1120 lb. on the square inch ; and off the coast of Portugal there is a great fishery of sharks (*Centrocymnus cælolepis*) carried on beyond that depth.”

Acclimatisation of Plants and Animals.

280. As in the vegetable world, so also (though to a less extent) in the animal, certain species have a special elasticity of constitution, which enables them to subsist under a greater variety of conditions, and naturally, therefore, to enjoy a wider geographical range. Operating upon this principle, and a knowledge of climatology, man has been enabled to transfer from one region to another

a considerable number of animals, either for the purposes of his convenience or luxury. All the domestic animals—horse, ass, ox, sheep, goat, pig, dog, cat, barn-fowl, &c.; many birds, prized for their beauty or song; and rats, mice, insects, and other creatures, considered as “pests and vermin,” have accompanied him over the habitable globe. His efforts in this respect—extirpating, transferring, and acclimatising—have been incessant; and thus creatures naturally of widely distant habitats have been, and are still being, brought together into one common area. In this way the domestic animals of the Old World have been transferred to the New, where they were unknown at the time of its discovery by Columbus; some of the New World fauna transferred to the Old; and not only the domestic animals, but the birds, fish, and even shell-fish of Europe, transported to Australasia, where, within little more than a century, their genera were totally unrepresented. But as in the vegetable world, so in the animal, there is a limit to this system of transference, and man best studies his own interest and the comfort of the lower animals, by fostering them mainly within their own native habitats, and sharing in their larger produce through the more profitable method of commerce and exchange.

Interdependence of Plants and Animals.

281. As plants and animals are alike dependent on external conditions, so both are, to a certain extent, dependent on one another. Both, for example, are dependent on the atmosphere, yet the oxygen which the plant sets free is inhaled by the animal, and the carbonic acid exhaled by the animal is decomposed and its carbon assimilated by the plant. The plant, rooted in the soil and casting abroad its leaves and branches in the atmosphere, though seemingly deriving the main elements of its growth from inorganic sources, is nevertheless stimulated into life and exuberance by the presence of organic decay, and many of the lower fungus-growths are found only where such decomposing matter is present. Herbivorous animals, as is well known, subsist directly upon plants, while the carnivorous prey upon the plant-feeders, and are thus also ultimately dependent on the vegetable world for their subsistence. Wherever vegetable life is varied and luxuriant, there animal life is marked by a corresponding variety; hence the specific exuberance of the tropics compared with that of the colder latitudes. And yet the student requires caution against the application of this obvious generalisation. Excess of

vegetation is not always an index to a gigantic fauna ; nor does a diminutive fauna at all times result from the growth of a scanty flora. The vegetable luxuriance of the Amazonian Plain is accompanied by an insignificant fauna ; while a scanty flora and gigantic fauna are concomitants in Southern Africa. Beyond the tropics, where winter periodically suspends the life of the forests and meadows, the vegetable-feeders hibernate or migrate ; while the animal-feeders, in turn, either migrate or betake themselves to the same periodical repose. By the extirpation of certain plants, certain mammals, birds, and insects may be removed from a district ; while, on the introduction of some new exotic, animals hitherto unknown in that locality usually make their appearance. Certain birds, for example, feed on certain insects, and these insects, again, find their chosen food in certain plants ; remove the plants and you destroy the insects, and by the destruction of the insects you compel the birds to remove and find supplies in other habitats, or if these supplies cannot be found the birds are extirpated. The law of circulation and interdependence is complete, and no portion of the circle could be removed without a corresponding change in the characters of the vegetable and animal kingdoms.

282. Again, though most plants have the inherent power of dispersing their own seeds, and are aided in this by winds and water-currents, yet many depend upon birds and mammals for their wider dispersion and increase, just as many depend upon insects for the fertilisation of their flowers. This wider dispersion creates a new source of subsistence for the animals that feed upon them, and thus the increased area of the one supplies a wider range to the other. Further, as some animals are fitted by their organisation for an arboreal existence—some for life on the grassy plain, and others for the shrubby thicket—the destruction of the tree, the planting of the plain, or the clearing of the thicket, would necessarily involve the destruction of these special organisations. Still further, as some creatures are specially fitted to live on fruits, some on leaves, and others on roots, the disappearance of these specific supplies would necessarily be followed by the annihilation of the consumers. It is in this manner that plants and animals become co-dependent portions of one great vital plan, and that geographers, aware of these relations, can more intelligibly depict the aspects of nature by associating every fauna with its own appropriate and distinctive flora.

“The richness of the Fauna is thus in intimate connection,” says M. Reclus, in his ‘Ocean, Atmosphere, and Life,’ “with that of the Flora ; where vegetation springs from the soil with most

vigour and abundance, there also animals live in the greatest multitudes. Nevertheless, we must not think that the animals of the largest size inhabit precisely those countries where the most gigantic trees grow. In this respect there is rather a contrast—the great pachyderms of Africa feed on plateaux destitute of trees in many places, and covered with thin grass; the enormous white bear of the northern regions inhabits snow and ice fields far removed from all forest vegetation. On the other hand, the splendid forests of Brazil give shelter to relatively small species; the largest being the tapir, much inferior in dimensions to the huge animals of Africa. The most remarkable fact in the present distribution of the largest species of animals is, that they inhabit the most extensive countries. It is in the Old World that the largest members of the animal kingdom live—the long-tailed monkeys, tapirs, vicunas, jaguars, and pumas of America, being much less in size and strength than the gorillas, elephants, camels, tigers, and lions of Africa and Asia.”

NOTE, RECAPITULATORY AND EXPLANATORY.

In the two preceding chapters attention has been directed to the vital aspects of the globe—that is, to its vegetable and animal life, and their distribution over the land and through the waters. Leaving the nature and origin of Life to the biologist, we have shown that plants and animals are dependent for their continuance on the external conditions by which they are surrounded, and that any change in these conditions would materially affect, if not destroy, their existence. For this reason, plants and animals have a definite distribution over the globe; heat, light, and moisture being the great regulators of the one; climate and food the governing conditions of the other. In this way vital variety and exuberance culminate within the tropics and decline as we proceed towards either pole—declining also in an analogous manner as we ascend from the level of the sea into the higher elevations of mountains. Each zone or belt of the earth has thus its own special flora and fauna—that is, is characterised by genera and species not naturally occurring in other regions. As marked variations occur within narrower limits than the torrid, temperate, and frigid zones, botanists subdivide the earth's surface into equatorial, tropical, sub-tropical, warmer-temperate, colder-temperate, sub-arctic, arctic, and polar belts; and these, as might be expected, correspond with lines of temperature rather

than with parallels of latitude. As in the land, so also in the waters, each zone of depth, from the shore seaward, has its characteristic forms—littoral, laminarian, coralline, and coral; the extreme abysses of ocean, like the extreme altitudes of land, being barren of all but the most lowly vegetable forms, though in certain areas of these abysses certain forms of invertebrate life have been found to flourish in abundance, and this because the conditions of extreme depths are more uniform and less rigorous than those of extreme altitudes.

Beyond these main horizontal and vertical arrangements of life, there is also an aboriginal dispersion of certain races over certain areas which science cannot yet fully account for; hence the subdivision of the earth's surface into botanical and zoological "regions" and "provinces," each subdivision being characterised by its own typical forms. These provinces form the special study of the botanist and zoologist; and the question how far the plants and animals of one region can be profitably transferred to another, becomes one of prime economical importance. Understanding the geographical conditions under which plants and animals naturally occur, and knowing, moreover, the intimate interdependence of the vegetable and animal kingdoms, man, in his own migrations over the globe, will be better able to determine what to cultivate and what to extirpate, what to attempt acclimatising and what to continue in their own native habitats. Understanding, moreover, the relations that subsist between fauna and flora, he will, as a geographer, be better enabled to draw that intelligible picture of external aspects which it is the grand province of his science to depict; and from a knowledge of these aspects be further enabled to indicate to the merchant and trader the nature and amount of the products which each separate region can supply.

The student who would enter more fully into the distribution of vegetable and animal life may consult for the former such works as Balfour's 'Class-book of Botany,' Lindley's 'Vegetable Kingdom,' Schouw's 'Earth and Man,' Meyen's 'Botanical Geography,' Reclus' 'Ocean, Atmosphere, and Life,' and the various publications of Humboldt, Hooker, Bentley, Dyer, and others who have written on botany; and for the latter the letterpress of Johnston's 'Physical Atlas,' the zoological works of Cuvier, Milne-Edwards, Carpenter, Carus, Owen, Huxley, Nicholson, &c.; and the various writings of Wallace, Darwin, Edward Forbes ('Natural History of the European Seas,') Sir Wyville Thomson ('Depths of the Sea,' 'The Atlantic,' and Challenger Reports), and the like, who have ventured on the higher questions of zoological geography.

XV.

ETHNOLOGY—RACES AND VARIETIES OF MAN.

Man as affected by External Conditions.

283. MAN, in whatever stage of civilisation he may appear, is always more or less influenced by the geographical conditions of the region he occupies. Unlike the lower animals, which either simply flourish under or succumb to these conditions, Man may struggle against and so far modify them ; but still, to a great extent, his thoughts and actions, his industrial pursuits, his social polity and religious beliefs, are all affected by the physical circumstances of his position. To argue otherwise were to ignore the principles of science, and lose sight of those zoological relations that subsist not only between man and the other animals, but between him and those physical surroundings upon which the continuation of his existence is so absolutely dependent. In savage life this influence is direct and perceptible ; hence the difference between the semi-aquatic Esquimaux and the hunting Red Indian, though inhabiting the same continent ; between the stationary vegetable-feeding islanders of the sunny Pacific, and the wandering omnivorous tribes of the scrubby plains of Australia ; between the lithe and nerveless red man of the New World, and the robust and vigorous negro of the Old. Even where civilisation has made some progress, it is these conditions that still mainly determine man's habits and pursuits—rendering the inhabitants of the grassy steppe nomades and herdsmen, the indwellers of the river-plain tillers of the ground and growers of grain, and the men of the sea-coast traders and adventurers. And higher still, where populations have been long settled and civilisation has assumed its most advanced aspects, climate, scenery, natural products, facilities for intercommunication and exchange, are ever exercising their influence—rendering one nation wealthy and independent,

another bold and enterprising, and a third, it may be, isolated and stationary. Nor is it man's mere material condition that is thus affected ; his religious sentiments, his poetic feelings, his love of liberty, his social government, are all less or more tinctured by the nature of his geographical surroundings.

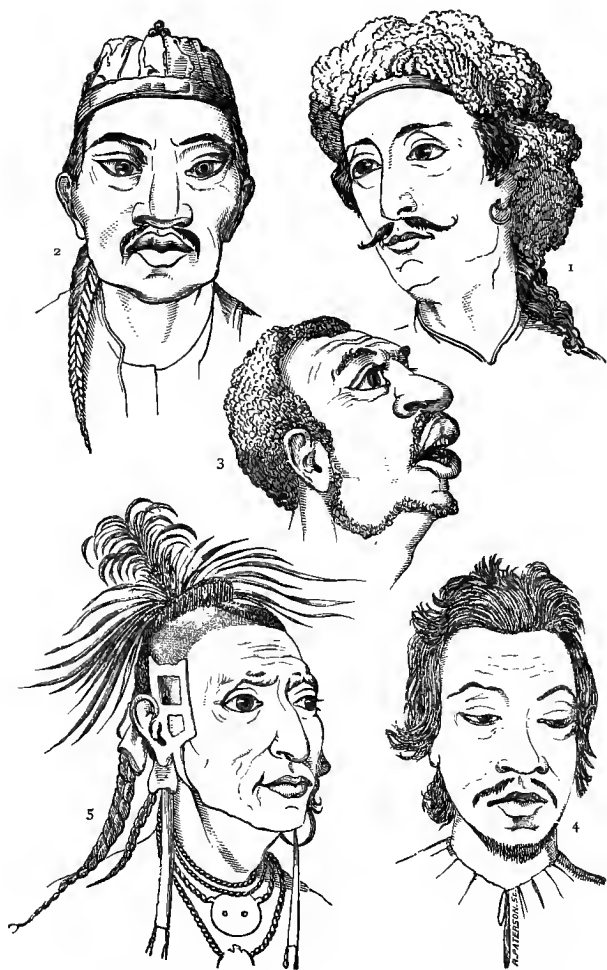
284. That such is the case, the most cursory glance at the different nationalities of the world will readily convince ; and though the inherent qualities of Race, for reasons we cannot now discover, may differ very widely, still over and above these qualities external conditions exert a direct and perceptible modifying influence. The white men of Europe may differ physically and intellectually from the black tribes of Africa and the red races of North America ; but it may be fairly questioned whether the former would have ever exhibited their present activity and progress had it not been for the greater varieties of surface, climate, and general physical conditions that Europe, as a continent, enjoys. There can be no doubt that the moderate climate of Britain is more favourable to bodily and mental vigour than the relaxing temperature of the tropics ; and that the slight seasonal differences between our spring, summer, autumn, and winter, induce habits of continuous exertion and industry unknown in countries subjected to excessive summer's heat and winter's cold. But for our insular situation, our countrymen would never have been the traders and adventurers they have become ; and but for our natural supplies of coal, iron, and other metals, the mechanical and manufacturing character that now stamps the British nation would have been impossible. So much does the general character of a people depend upon the physical or geographical conditions of the country they inhabit !

285. Even in their minor peculiarities, the different nations of the same great race are similarly affected by external conditions : hence the obvious distinctions existing between the livelier and more versatile nations of southern Europe and the graver inhabitants of the north ; between the bold and independent mountaineers of Switzerland, Scotland, and Scandinavia, and the tamer occupiers of the central and eastern European plain. Climate, food, landscape—all, in fact, that constitutes geographical diversity—must exercise an influence on mental as well as on bodily character ; and were it not so, there is no reason why the inhabitants of one country should not be identical in all their aspects with those of another. The language of everyday life, however, is full of such distinctions, and this long before science had attempted their explanation. Thus we speak of the “dry, clear, exhilarating air” of one district, and the “damp, cloudy, and depressing at-

mosphere" of another : of the "dreary monotony" of one region, and the "charming variety" of another : of the "awe-inspiring gloom" of the forest, and the "cheerful hues" of the open landscape. Indeed it is to the influence of situation that we are in a great measure to look for many marked national peculiarities—these peculiarities diminishing the more that nations extend their range of intercommunication, and the less they are restricted to their own narrow boundaries.

Characteristics and Distribution of Races.

286. Whatever the influence of external conditions in modifying the characteristics of race, we find Man distributed at present over almost every region of the globe—wandering in savage freedom under the tropics, flourishing in busy communities within the temperate zones, and struggling in diminished numbers against the inclemencies of the polar regions. Within the tropics he is chiefly a vegetable feeder ; in the temperate zones he adopts a mixed vegetable and animal diet ; while within the polar circle his diet is exclusively animal. But while in this respect he obeys, like plants and animals, the zonal arrangements of the world, unlike them the varieties of his race are distributed according to no law of latitudinal dispersion. As in districts of the same country we find differences of stature, physiognomy, dialect, and habits ; so in the various countries of the same continent we find still wider differences in bodily appearance, mental constitution, language, and manners. Notwithstanding these well-known distinctions, there is among the inhabitants of certain regions a certain sameness in physical aspect, in colour of skin, in form of head and face, and also in mental disposition, that stamps them as distinct from the inhabitants of other regions ; hence arises the idea of *varieties* or *races* of the human species. That these varieties or sub-species (for the difference seems greater in some instances than what zoologists regard as characterising varieties) have existence in nature, we have only to look at the condition of mankind, as at present scattered over the surface of the globe. Here, active, intelligent, and progressive ; there, sluggish, dull, and stationary : here, enjoying the highest amenities of civilisation ; there, grovelling in a condition little elevated above the brutes by which they are surrounded. And not merely do they differ in intellectual qualities, but in physical organisation, in mien and stature, in form of head and expression of face, in colour of skin, in strength and endurance, and, in fine, in all those purely



1. Caucasian; 2. Mongolian; 3. Ethiopian; 4. Malay; 5. American.

bodily qualities by which one species of animal is distinguished from another.

287. Without entering upon the vexed question of man's origin and antiquity,—whether he is a mere development from the lower animals, according to some great natural plan, or an entirely new creation—whether he has been six or sixty thousand years an inhabitant of the earth—and whether the varieties of our race have descended from a single pair, and been since modified by external conditions, or are the progeny of several independent pairs,—it may be stated as the general opinion of naturalists that the races of mankind (as they now exist) constitute in the zoological scale a single species of a single genus. But though he thus stands unique, and far exalted above other animals by his gifts of reason, moral perception, and religious sentiment, it is necessary and natural to divide mankind into several varieties according to their more prominent bodily features; and Ethnology (Gr. *ethnos*, a race; *logos*, a discourse), extending the subject to minor features, language, and the like, still further subdivides these varieties into groups, tribes, and branches. The consideration of these minor distinctions (which are evidently produced by intermixture of races and the influence of external conditions) belongs more especially to Ethnology; our limits will merely permit a brief allusion to the *five* varieties or races into which the inhabitants of the globe were arranged by the German philosopher, Blumenbach, about a century since (1781), a grouping which (though admittedly tentative) has had great effect in systematising our knowledge upon the subject. These are the *Caucasian*, the *Mongolian*, the *American*, the *Ethiopian*, and the *Malay*; each being characterised by some peculiarity in colour of skin, eyes, nature of hair (curled, lank, woolly, frizzled), shape of skull, form of face, and general physiognomy. Of these physical characteristics, colour of skin is one of the most obvious, and, though varying in shade even in the same race, is yet employed in everyday language as a main mark of distinction—the Caucasian being the *white*, the Mongolian the *yellow*, the American the *red*, the Ethiopian the *black*, and the Malay the *brown*. The distribution and more obvious characteristics of these respective races we epitomise from Blumenbach and other ethnologists:—

288. The *Caucasian* variety is dispersed over Turkey, Arabia, Persia, part of Tartary, Afghanistan, and Hindostan, in Asia; over Egypt, Abyssinia, and the Mediterranean seaboard, in Africa; and over almost the whole of Europe;—the Turks proper, the Magyars, Finns, and Laplanders, being of Mongolian origin. Within the last three centuries the race has spread from Europe

over large areas of North and South America, South Africa, Australia, and New Zealand ; and wherever it has planted itself becomes the dominating power. This variety was named Caucasian by Blumenbach, merely from the fact that the skull he selected as his highest type came from the neighbourhood of the Caucasus. It is also known by the term *Indo-European*, from its spreading over India and Europe from the Ganges to the farther shores of Iceland. The more important branches are the Hindoo, Persian, Arab, Circassian, Slavonic, Teutonic, and Celtic, with their various mixtures and alliances, which now constitute the nationalities of southern Asia and Europe. Of course, thousands of years have passed away in the development of these respective branches—each branch springing out from its predecessor, and assuming new features in body, mind, language, and beliefs according to the nature of its new region, though still retaining enough of the original stock to mark its origin and descent.

289. The distinguishing characteristics of these Indo-Europeans are—a light-coloured skin, varying from fair to tawny or swarthy ; red cheeks ; copious, soft, flowing hair, generally curled or waving ; ample beard ; small, oval, and straight face, with features distinct ; expanded forehead ; large and elevated cranium ; narrow nose ; and small mouth. In stature the Caucasian is taller than any of the other varieties ; of erect gait ; with rounded, well-proportioned limbs ; moderately small extremities ; and light, elastic step. The *White* race (for by this designation it is generally distinguished) has given birth to the most civilised nations of ancient and modern times ; and has hitherto exhibited the intellectual and moral powers of human nature in their highest degree. Wherever the white man has established himself, the other races disappear before him. His proper field of development, however, seems to be the temperate zones in either hemisphere, for beyond them he degenerates physically and intellectually, and loses the higher characteristics of his race. And even as regards the whole species, it is held by some that “Man presents to our view his purest, his most perfect type, at the very centre of the temperate continents—at the centre of Asia-Europe, in the regions of Iran, of Armenia, and the Caucasus ; and, departing from this geographical centre in the three grand directions of the lands, the types gradually lose the beauty of their forms in proportion to their distance, even to the extreme points of the southern continents, where we find the most deformed and degenerate races, and the lowest in the scale of humanity.”

290. The *Mongolian* variety is spread, as the name implies, over the central and northern regions of Asia—Mongolia, China, Japan, Burmah, and Siam ; and includes, moreover, the scattered inhabitants of the Arctic seaboard, both in the Old and New World continents. It embraces the Mongols, Turks, Tibetans, Chinese, Indo-Chinese, Japanese, Kamtchatdales, Tungusians, Koriaks, and Samoiedes, in Asia ; the Turks, Finns, and Lapps, in Europe ; and the Esquimaux of the North American arctic regions. In the Mongolian the skin is olive yellow ; the hair dark, coarse, and straight ; little or no beard ; head or cranium somewhat square-shaped ; forehead rather low ; face broad and flattened, with confluent features ; high cheek-bones ; eyes rather sunk, and obliquely directed towards the nose ; wide and small nose ; and thick lips. In stature the Mongolian is below the Indo-European ; but in the true Tartar, Turk, and Chinese, the frame is broad, square-set, and robust, with high shoulders, and short and strong neck.

291. In intellectual and moral capacity the various branches of the race differ very widely ; but on the whole they are inferior, less energetic, and more stationary in their civilisation than the Caucasian variety. “With the Mongol,” it has been remarked, “the melancholic temperament seems to prevail ; the intellect, moderate in range, exercises itself upon the details, but never rises to the general ideas or high speculations of science and philosophy. Ingenious, inventive, full of sagacity for the useful arts and conveniences of life, it nevertheless is incompetent to generalise their applications. Wholly turned to the things of earth, the world of ideas—the spiritual world—seems closed against him. His whole philosophy and religion are reduced to a code of social morals limited to the expression of those principles of human conscience without the observance of which society is impossible.” Socially and morally, the highest attainments of the race appear in the Chinese and Japanese, the Turks and Magyars having been so long amalgamated with Europeans as to assume a Western rather than an Oriental phase of civilisation. How far, and in what direction, the Mongol is capable of adopting and being influenced by European ideas will shortly be tested by the recent awakening of the Japanese—not only to permit of trade and interchange between them and the white men of Europe and America, but to invite the whites to settle among them, to adopt freely their mechanical and industrial appliances, and, above all, to send out many hundreds of their young men to acquire a knowledge of the Arts and Sciences in England and the United States. Few revolutions in human history have been so sudden and de-

cided; no subject can be of greater interest to the philosophical ethnologist than its final outcome.

292. Under the *American* variety, ethnologists comprise all the aboriginal races which peopled the New World prior to its discovery by Columbus in 1492. These are the Chippewyans, Sioux, Pawnees, Cherokees, and other tribes in North America; and the Caribs, Solimoes, Guaranis, Araucanians, Patagonians, and Fuegians in South America. In this race the skin is reddish or copper-coloured (hence the familiar designation of Red Indian); the hair is black, coarse, and lank; beard scanty; skull somewhat similar to the Mongolian, but narrower, and not so square; forehead low and retreating; cheek-bones prominent, but more rounded than those of the Mongol; eyes sunk, and somewhat raised at their outer angle; nose and other features rather prominent. In stature the North American Indian is rather tall; spare and lithe in body; and as a hunter, acute in his senses, and remarkable for his endurance of fatigue and insensibility to pain. In South America the race greatly degenerates; the Guaranis, the Fuegians, and other tribes being amongst the most degraded of savages, their wretched appearance being in many instances aggravated by artificial distortion of the head and facial features.

293. In intellectual and moral qualities the American Indians resemble in many respects the Mongolians. Like the Mongols, they have remained stationary, but at a much lower point of civilisation, if we except the ancient occupants of Mexico and Peru, whose geographical position seems to have imparted to them a greater degree of energy and activity. In North America the race is rapidly disappearing before the white settlers; in South America, less fitted for the White, the inferior and more sparsely scattered tribes have been little interfered with. "The indigenous man of America," says M. Guyot, "bears in his whole character the ineffaceable stamp of the peculiarly *vegetative character* of his country. Living continually in the shadow of those virgin forests which overspread the earth that he inhabits, his whole nature has been modified thereby. The very copper hue of his complexion indicates that he lives not, like the negro, beneath the scorching sunbeams. His lymphatic temperament betrays the preponderance in his nature of the vegetative element. The Indian is of a melancholy, cold, and insensible race. Foreign to our hopes, our joys, our griefs, it is rarely that a tear moistens his cheek, or a smile lights up his eye. The most barbarous tortures cannot extort from him a single complaint, and his stoical indifference is disturbed only by vengeance or jealousy. If he sometimes exhibits a display of prodigious muscular force, he is

yet without endurance. . . . The social condition of the Indian tribes is hindered, in an equal degree, by the powerful influence of his vegetative character. The Indian has continued the man of the forest. He has seldom elevated himself above the condition of the hunter, the lowest grade in the scale of civilisation. The exuberance of the soil has never been of value to him, for he asks not of the earth his nourishment. He has never even ascended to the rank of the pastoral man. With him no domestic animals are maintained to feed him with their milk, or clothe him with their fleeces, as they are by the nomadic races of the Old World. From one to the other extremity of America we find the same lamentable spectacle ; the people of the elevated tablelands of Mexico and Peru are the only exceptions to this picture, and this exception goes far to establish the influence of the vegetative and humid nature of the lower plains of America."

294. The *Ethiopian* race, in one or other of its branches, inhabits the whole of Africa, with the exception of Egypt, Abyssinia, Tunis, Tripoli, and Morocco on the north, and Cape Colony on the south. It embraces Hottentots, Bushmen, Kaffirs, Negroes, Gallas, Tibboos, Mandingoes, and other tribes, differing widely among themselves in physical and mental aptitude, but all, from time immemorial, remaining in a barbarous or but very partially civilised state. In this variety, which derives its name from the Ethiopia of the ancients, the skin is black (hence the familiar designation, Negro—Lat. *niger*, black) ; the hair short, black, and woolly ; skull compressed on the sides, and elongated towards the front ; forehead low, narrow, and slanting ; cheek-bones very prominent ; nose broad and flat ; jaws projecting so as to make the upper front teeth oblique ; lips, especially the upper one, very thick. In stature there are great differences among the different branches of the race—some, like the Kaffir, being of average size and fairly formed ; others, like the true negro, also of average size, but ungainly in form and limb, with large, flat feet and hands, and shuffling, awkward gait ; and some, again, like the Hottentot and Bushmen, of stunted stature, and with slender, ill-formed limbs. Intellectually, the Black race has ever remained in a rude and barbarous state ; hence the subjection of one branch to another branch among themselves ; and hence, also, their enslavement, from time immemorial, by the white variety. This is not the place to enter upon the question, how far the negro is capable of attaining the higher phases of civilisation ; but the fact remains, that neither of himself, nor in any of his admixtures with other races, has he shown much aptitude for intellectual or social advancement. Even in the fine

genial clime of the highlands of equatorial Africa, as described by Captain Speke, the negro remains much the same—easy, indolent, sensual, enslaving or enslaved, but never rising to the higher conceptions of social or moral polity, and still less to the attainments of science or philosophy.

295. The *Malay* race (so called from the Malayan peninsula) includes the widely-scattered and chiefly insular inhabitants of Malaysia, Australasia, and Polynesia. The population of these widely-spread districts differ, as might be expected, very widely from each other—those of Malaysia and Polynesia being of a brown or lighter colour, and somewhat resembling the Mongolians; while those of New Guinea and Australia (the Papuan negroes, as they are termed) are of a dark colour, and more closely approximated to the negro type. Intellectually, also, there is a similar difference, there being little in common between the Malay of the Indian Archipelago and the savage inhabitant of New Guinea; between the stunted and miserable native of Australia, and the daring, apt, and clever inhabitant of New Zealand; or between the calculating nature of the New Zealander, who lives under a temperate climate, and the mild, facile, and careless character of the true islander of the sunny Pacific. Taken, however, as described by ethnologists, the skin of the Malay varies from a light tawny to a deep brown; hair black, crisp, and somewhat inclined to curl in the true Malay, and tufted and frizzled in the Papuan; head rather narrow; bones of the face large and prominent; nose full and broad towards the lips. In civilisation the Malay race has hitherto made little advancement. In the Indian Archipelago it has, like the Mongolian, long remained stationary; in Polynesia, some progress appears under tutelage of the white, though the areas are apparently too small and too widely separated ever to be of much importance; in New Zealand it seems reluctant to amalgamate with the new settlers; while in Australia it is rapidly dying out before the encroachment of the European immigrant.

Such, in general terms, is Blumenbach's arrangement of the Races of Mankind. It has been, in great part, superseded by other and more elaborate schemes of classification; but none have as yet been propounded which have met with such general acceptance. The most complete of these more recent schemes is that of Professor Huxley, who distinguishes four chief races of mankind, typified by (a) the Australian, (b) the Negro, (c) the Mongol, and (d) the European or White man. The *Australian-like* race includes the Australian aborigines, and the Coolies of Southern India. The *Negro-like* race embraces the Negroes proper, and also the Bush-

men, and the Negro-like inhabitants of some of the East Indian Islands. The *Mongolian* race not only includes the Mongols proper, but also the Malays, Polynesians, and American Indians. The *White* Race is supposed to be composed of two main varieties—the *Pale Whites* and the *Dark Whites*; the former including the people inhabiting the inland region lying between Britain and India, and the latter embracing the Celts, Spaniards, Greeks, and Arabs.

296. But, retaining Blumenbach's scheme as an aid to the general arrangement and consideration of mankind, we must remember that there are not only admixtures among conterminous races (Caucasian and Mongol, Mongol and Malay, Mongol and American), but admixtures also between immigrant and native races (Brazilians, Peruvians, Mexicans, &c.), which render sharp lines of demarcation impossible, and unnecessary as impossible. The consideration of these *minutiae* belongs more especially to Ethnography and Philology, by which not only shades of colour, types of skull, facial angles, and the like, are taken into account, but dialects of language, mental peculiarity, and forms of government, are all considered in tracing the dispersion, affinities, and history of the human race. Such considerations lie beyond the scope of our Outline, and the student of physical geography may consider as sufficient for his purpose the *five* great varieties above enumerated, or even their abridgment into *three* (Caucasian, Mongolian, and Ethiopian)—reckoning the American as a sub-variety of the Mongol, and the Malay a sub-variety partly of the Mongol and partly of the Negro. It is the general features merely that our science aims at; the details of nationality, of language, and the progress of civilisation belong to History, Ethnology, and Philology, and would require volumes for their special treatment and elucidation. And even as regards these sciences, it must be confessed that many of their conclusions are as yet unsatisfactory, and must remain so till man is considered more from a Natural History point of view, and less as a being apart from the other relations, physical and vital, of the universe. Anthropology, or the natural history of man, treated in the same manner as the natural history of other animated beings, is a study that is as yet in its infancy; but it is one which is destined to a high place among the branches of human knowledge.

Conditions of Civilisation and Progress.

297. Such is the usual subdivision of mankind into varieties or races, and such the existing distribution of these races over the

surface of the globe. The subdivisions may to some extent be arbitrary ; but as there are actual differences of colour, form of head, facial expression, and the like, and as these physical features are accompanied by strongly-marked differences in mental constitution, in form and structure of language, and in intellectual capability, the distinctions in the main must be founded on nature. As to the prehistoric distribution of man, neither archæology nor geology, in the absence of reliable remains, can arrive at any certain conclusion. Within historical time, however, the various races, while peopling most densely the regions they now occupy, have ever been less or more encroaching on each other's domain—the inferior giving way to the superior and more civilised. The Ethiopian, in its numerous tribes and branches, has remained stationary in Africa. The Malay, chiefly an insular race, has spread itself, in one or other of its branches, over the islands of the Southern Ocean and Pacific. The Mongolian, while claiming Central and Eastern Asia as its headquarters, has spread partially into Europe, and largely along the entire seaboard of the Arctic Ocean. The White man, on the other hand, has partly repelled the Mongol, and, after spreading wave after wave over Western Asia, Northern Africa, and the whole of Europe, has within the last three centuries taken possession of the greater portion of North America (United States, Canada, Mexico, California, &c.) ; of part of South America (Brazil, Guiana, Peru, &c.) ; of South Africa ; and of Southern Australia and New Zealand ; while his influence is felt, less or more, in every region of the globe.

298. Wherever the means of subsistence can be obtained, there man will establish himself and increase in numbers—his increase being mainly regulated by the facility or difficulty of obtaining supplies. Where he can raise more than his own wants require (and this will depend very much on his knowledge of nature's laws and operations, or on the natural capabilities of his Race), or where he enjoys products not possessed by other localities, this surplus and these products form subjects of barter and exchange, and thus he acquires wealth and the power to command luxuries. Raised above the mere physical struggle for existence, the higher faculties of his mind—imagination, invention, reflection, moral perception, and religious sentiment—begin to develop themselves, and man passes from the domain of savagery into the categories of civilisation. To trace the course of civilisation lies beyond the scope of our subject ; but it is evident, from what has been repeatedly stated, that its advancement (laying altogether aside the consideration of Race) depends, in a great

measure, on the geographical or physical conditions by which it is surrounded. Wherever there exists a favourable climate, the means of subsistence, and opportunities of interchange and barter—in other words, wherever there are the objects and means of successful industry—there civilisation will manifest itself; and just as equitable laws, protection of property, freedom of action, and liberty of opinion are enjoyed, so civilisation will advance in a corresponding ratio. It has passed, and may yet pass, from nation to nation; but in the aggregate its maintenance from epoch to epoch has been secure, and its progress seems illimitable.

299. It may be noted, however, that, other things being equal, a maritime or oceanic population will more readily excel in civilisation than a continental or inland one—their progress being directly as their means of interchange and intercommunication with other countries. Again, a population like that of China, enjoying vast and equable geographical conditions, will remain more stationary than another even of the same race (as the Japanese) who possess more limited but more varied surroundings. Further, populations cut off from intercommunication by land-barriers, such as vast deserts and mountain-chains, remain more isolated and less progressive than others separated by the widest oceans; hence the sharp definings of certain Asiatic races, such as those of China, India, Tartary, and Arabia. Still further, variety of external conditions and variety of natural products necessarily produce greater contrasts, greater activity, and greater intelligence; hence the varied and superior civilisation of a diversified continent like Europe compared with the other great sections of the globe. In fine, the effect of geographical condition and its necessary accompaniments is too often lost sight of in our social and political reasonings; and it may be laid down as an axiom, that no great continent possessing different climates, different products, and necessarily different races, can possibly be governed by the same laws, or permanently united under the same forms of government. It is true, the tendency of modern times is towards a closer unification of the human race—a breaking up and absorption of small states and principalities analogous to the earlier breaking up and absorption of smaller states and chieftaincies at the commencement of the feudal system; but notwithstanding this tendency and most desirable result, there will ever be among the human dwellers of each of the larger continents (even within the same great section) minor diversities and contrarieties of bodily structure, mental aptitude, disposition, industrial pursuit, which have been, and are being, evolved and regulated by immediate physical surroundings.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter attention has been briefly directed to the varieties and distribution of the human species—Ethnology and Ethnography being the sciences which treat of these distinctions—the former devoting itself to the descriptive details, the latter to the rational exposition of the subject. It has been shown that Man, though possessing a greater elasticity of constitution than most of the lower animals, and capable of enduring under almost every climate, is still, to a great extent, influenced by the external conditions by which he is surrounded, both in his physical and mental relations. Whether owing to these influences, or arising from aboriginal differences which science cannot explain, Man now appears in several *varieties* or *races*—each occupying well-marked territories on the globe, and distinguished by peculiarities of colour, form of head, facial expression, and other *physical* features, as well as by equally obvious *intellectual* and *social* qualities. According to Blumenbach's scheme, these varieties are the *Caucasian* or *white*, the *Mongolian* or *yellow*, the *American* or *red*, the *Ethiopian* or *black*, and the *Malay* or *brown*—each embracing a great number of tribes, branches, and nationalities, differing in language, social polity, and other peculiarities.

The Caucasians, or Indo-Europeans, inhabit the south-western section of Asia, the northern belt of Africa, and nearly the whole of Europe, and have, in modern times, extended their dominion to large areas of North and South America, South Africa, South Australia, and New Zealand. The Mongolians, concentrated chiefly in Central and Eastern Asia, have partially penetrated into Eastern Europe, but are most extensively spread in scattered communities along the entire seaboard of the Arctic Ocean. The Malays, having their headquarters in Malaya and the Indian Archipelago, are spread, in one or other of their tribes, over Australia, as well as over all the island groups that stud the bosom of the Pacific. The Ethiopians, though drafted hither and thither as the slaves of the white man, have been mainly stationary in Africa, the natural home and habitat of their race; while the Americans, or Red Indians, have been equally restricted to the New World continent. As a whole, the negro and Red Indian have made, and still make, the least progress in civilisation; hence their easier subjection by the higher races, and hence also their rapid disappearance before them. The Malay and Mongolian come next in order; and though some of their sections (Chinese, Japanese, &c.) have arrived at considerable eminence in the industrial arts, yet in both races the essentials of higher progress

seem wanting, and hence their torpid and stationary aspect. The recent awakening of Japan to the arts and industries of European civilisation forms one of the most wonderful episodes in human history, but it is yet too brief and partial to constitute the basis of any satisfactory deduction. By the white race alone do we find displayed the higher efforts of bodily and mental activity—hence in ancient times the civilisations of India, Assyria, Palestine, Egypt, Phœnicia, Greece, and Rome; and in modern times those of Western Europe—Austria, Germany, France, and Britain; of the United States and Canada; and, generally, of European colonies, in whatever region of the globe they may happen to be established.

The conditions favourable to this civilisation are partly of a geographical or physical nature, and partly intellectual; and wherever the two are in fortunate conjunction, there the progress of the white race is certain, and illimitable as certain. We say of the *white* man, for as yet neither of the other varieties have at all approached the standard of his civilisation in temperate zones. Indeed it may be fairly questioned, on psychological grounds, whether they are naturally capable of the same kind and degree of social, moral, and intellectual attainments; and also whether, in all the temperate and sub-tropical regions at least, they are not in time destined to disappear before the spread and progress of the white, or to be imperceptibly absorbed into his superior numbers and advancement. Under the equatorial zone—and be it observed that only a very small portion of the land-surface is strictly equatorial, and even of that portion a considerable share, like the highlands of equatorial Africa, Mexico, and Colombia, are capable of being inhabited by the white man—the black and brown races, in some of their offshoots, may rise to a subordinate civilisation; but everything we know of the past points to illimitable progress in the white, and to a limit and declension in the other varieties of our species. This line of progression in Man is but part of the great law of vital evolution, which proceeds by the removal and extinction of the less fitted and elastic, and by the introduction and spread of the higher and more adaptive; and though benevolent schemes of amelioration may retard its effects for a while, they can neither arrest its operation nor divert its course.

The student desirous of entering more minutely into the study of Ethnology and its kindred branches, may consult such works as those of Prichard, Latham, Quatrefages, Tylor, and Lubbock; the plates and letterpress in the 'Physical Atlas' of A. K. Johnston; the 'Descriptive Sociology' of Herbert Spencer; and the articles on Anthropology and Ethnology in the recent edition of the 'Encyclopedia Britannica.'

XVI.

GENERAL REVIEW, APPLICATIONS, AND DEDUCTIONS.

Objects and Principles.

300. THE object of Physical Geography being not only to describe the external aspects of the world, but to determine the causes by which these aspects have been, or are still in course of being produced, it has been necessary, in the preceding chapters, to deal with principles as well as details. Indeed, our aim throughout has been to present our planet as subjected to general laws, as we believe that, when these are understood, there will be little difficulty in comprehending their modifications in local and limited areas. Let the student clearly understand the origin, for example, of winds and rains, of tides and currents, and he will soon find his way to determine the causes that produce their modification in any special locality. Let him once comprehend the main causes of climatic diversity, and the manner in which it affects the distribution of plants and animals, and he will have no difficulty in accounting for the peculiar climates of individual countries, or for the plant-life or animal-life by which they are peopled. The great object in an outline like the present is to inculcate principles; the details of geography would require volumes for their enumeration.

301. In accordance with these views, attention has been directed to the planetary relations of the earth—its figure, motions, dimensions, &c.—as on these depend its light and heat, its alternations of day and night, summer and winter, and, in general terms, all that gives rise to change and diversity in its external conditions. It is, in fact, to its solar relations that the earth owes, if we may so speak, its life and activity, deriving therefrom *directly* its rotation, revolution, heat, light, seasonal differences, and tides; and *indirectly* its winds, waves, and currents, its rains, snows, and

frosts—all that produces diversity in the distribution of its plants and animals, and change in the geological relations of its rocky exterior. It was necessary, also, to consider the detailed structure and composition of the globe, and the geological changes which, under the operation of aqueous, igneous, and meteoric forces, that structure has been and is still undergoing. On these forces depend the distribution of sea and land, the formation of highland and lowland, the production of soils, and all those exterior aspects which influence so decidedly the character and localities of the plants and animals by which it is peopled. This world of ours is one great interconnected scheme—an intricate network of interdependence, from which a single mesh could not be abstracted without deranging and marring the symmetry of the whole.

302. Seizing upon the present terraqueous aspects of the globe, and regarding its geological changes as only appreciable at long and distant intervals, we called the attention of the student, in the first place, to the relative distribution of its lands and waters—the disposition, highlands and lowlands of the one, and the configuration, depth, waves, tides, and currents of the other. Understanding the relations of land and water, and their necessary actions and reactions on each other, he was next directed to the study of the atmosphere by which both are surrounded, through which the light and heat of the sun are diffused to both, by which the plant-life and animal-life of both are sustained, and in which are elaborated the winds, rains, frosts, snows, and other phenomena that constitute the essentials of weather and climate. This all-encircling atmosphere is the great bond of union between land and water, between plants and animals, equalising and regulating the heat and moisture of the former, and conveying and supplying the vital gases so indispensable to the life and growth of the latter.

303. The consideration of this earth revolving through space as part of the solar system, composed superficially of land and water, surrounded by an atmosphere, and receiving heat, light, and other influences from the great central orb, constitute what may be termed the *physical* or *inorganic aspects* of geography. On the other hand, the study of the earth as peopled by plants and animals, and inhabited by man, capable of applying the whole to his own social and moral advantage, form its *vital* or *organic features*. In other words, the one relates to the *Physics* of the earth, and includes considerations merely of a mechanical and chemical nature; the other to its *Life*, and involves the more intricate problems of physiology and psychology. The study of the vital world, the distribution of its plants and animals, the causes

concerned in that arrangement, and the dependence of the one kingdom on the other, becomes therefore one of the most attractive themes in geography. Still higher, however, and of more immediate interest, is that which deals with our own race—the varieties of man, their physical and mental peculiarities, their dispersion over the globe, and the question how far geographical conditions, and the pursuits incident thereon, may influence their social, mental, and moral progress. Man in his settled and civilised condition becomes, no doubt, a modifier of nature ; but his control over nature is at the most only partial and limited, and, to be beneficial, must be in accordance with those great primordial laws which will ever lie over and beyond his influence, and to which, like the rest of creation, he must either conform or succumb.

304. But our science has its practical as well as theoretical importance, its economic as well as its scientific aspects. A knowledge of the distribution of sea and land—the winds, tides, and currents of the one, the highlands, lowlands, and climate of the other, and the mineral, vegetable, and animal products of both—is indispensable to successful navigation, commerce, and agriculture. The duty of determining the earth's mineral, vegetable, and animal products, and how far they can be rendered available for the purposes of everyday life, is not less imperative than the solution of its physical and vital problems. It is of vast importance to be acquainted with the character, abundance, and accessibility of nature's products, but it is not less important to learn how to apply them. All knowledge of nature is good of itself, but its value is doubly enhanced when it is made to minister to our common humanity. Combining, therefore, its theoretical with its practical bearings, and remembering that every country is characterised by its own natural products, and has consequently something that no other country can supply, Physical Geography has paramount claims alike on the attention of the philosopher, the statesman, the sailor, the farmer, the merchant, and the manufacturer.

305. The material wealth of the globe—that is, the products derivable from the mineral, vegetable, and animal kingdoms, and capable of being employed so as to administer to the comforts and luxuries of life—forms the leading theme of economic geography. Every country, in virtue of its geological formation, has some special mineral or metal in greater or less abundance ; and every region, in virtue of its position and climate, produces vegetables or animals peculiar to its own area. Man's ingenuity is ever on the rack for new inventions in the arts and manufac-

tures ; and as all his raw materials are drawn from one or other of the realms of nature, he turns to Physical Geography for indications of the character, abundance, and accessibility of the products that belong to the different countries of the globe. This search produces commerce, commerce brings about communion between the most widely diverse and separated regions, and this communion is the main incentive to civilisation and human progress. In this way Britain draws the raw materials of her manufactures from every accessible portion of the globe, returning thither her manufactured goods, and thereby creating new wants, new activities, new ideas, and all, in fine, that arises from the contact between superior and inferior civilisations. If the inferior, in consequence of its lower organisation and inaptitude, cannot be acted upon by, or amalgamate with, the higher, it gradually disappears, and makes room for the development of those higher conditions which seem to be the natural and destined end of the human species. The course of Humanity has been ever onward and upward—a triumph of mind over matter, a subjugation of the bodily to the intellectual, each age advancing with accelerated steps on the attainments of its predecessor. Wherever, therefore, there is the presence of unfavourable conditions, there will be a lagging behind ; wherever there is a want of aptitude, there must be a gradual deterioration, which must terminate, in the long-run, in utter extinction.

306. Such, in general terms, is the aim and scope of physical geography—to describe the lands and waters of the globe, the atmosphere by which they are enveloped, the mutual actions and reactions established between the elements in virtue of the planetary connections of the earth, the plants and animals by which they are respectively peopled, and finally, man's dependence on, and relationship to, the whole. In considering these phenomena, and in endeavouring to ascertain their producing causes, the geographer regards them as all under the operation of fixed and determinable laws. No appearance, however rare, no set of phenomena, however intricate, but must be the result of natural laws ; and the highest theme of his science is the discovery of these laws, and the resolution of the whole into one harmonious cosmos. But while he mainly deals with the existing aspects of nature, he cannot lose sight of the fact that these aspects are continually undergoing change and modification in virtue of the great operative forces of the universe. These changes may be all but imperceptible even for centuries ; but, in process of time, they become sufficiently apparent, and stamp new features on the ex-

ternal conditions of the globe. The air and water, ever wearing and wasting the rocky surface in one district and collecting the eroded material in another,—subterranean agencies, elevating the solid crust in one region and depressing it in another,—are ever changing the relative positions of sea and land; and thus the seas and lands of the future must differ from the seas and lands of the present, as those of the present differ from what geology assures us existed in time past. Every change of the external relations of sea and land, whether of distribution or of elevation and depression, implies a corresponding change in the nature and distribution of plants and animals; and here, again, the life of the future must differ from that of the present, as the present differs from that revealed to us by the researches of the geologist.

307. In this way the student of physical geography must regard the earth and all its relations—physical and vital—as being in a state of incessant change and progress. The changes may be slight—so slight as to pass unobserved for generations—yet still they are not on that account less real or certain. Bearing these facts in mind, we can more readily comprehend why the rocks (the old sea-sediment) of one region should differ from those of another, why the mountain aspects of the one should differ from those of the other, and why one tract should be low and alluvial while another is high and rocky—each feature being the product of a certain time and change in the earth's relations. In this way, too, we can understand the gradual formation of deltas, of sand-dunes along shore, of coral-reefs in mid-ocean, of the shoaling of certain seas and lakes, and the changes of plant-life and animal-life incident upon such alterations of habitat. History records the uprise of some sea-coasts and the depression of others, the appearance of new islands and the outbursts of new volcanoes, the increasing rarity of certain forms of life or their entire extirpation, the disappearance of certain forest-growths and the succession of others in their place, the extinction of certain aboriginal races of men and the spread of others over the same areas—changes which would often appear inexplicable but for this law of incessant mutation and progress. It is also by bearing in mind this great feature of ceaseless change that we can account for the similarities and differences that exist between the flora and fauna of different regions—regions that may at one time have been continuously connected by land, though now widely separated by expanses of ocean. The plants and animals of Britain, for example, claim kindred with those of Europe, and this through land-connections that existed long before their separation by the Strait of Dover.

It is, in fine, by carrying this idea of mutation into all our reasonings, that physical geography becomes a more intelligible part of World-history—connecting the past with the present, and preparing the philosophic mind for the nature of the changes that must ensue in the inevitably approaching future.

308. As formerly stated (Chap. III.), the chief agents concerned in the modification of the earth are the winds, rains, frosts, and snows elaborated in the atmosphere, which are ever loosening and disintegrating the exposed rocky surface ; the streams, rivers, waves, tides, and ocean-currents, which are incessantly wearing and wasting and redepositing the eroded materials along the bottom of the sea ; and the mysterious crust-movement, whose operations are alike incessant in upheaving and depressing the surface—now raising the sea-bed into dry land, and now submerging the dry land beneath the waters. No doubt, the consideration of these agencies belongs more especially to geology ; but their results bear so directly on the arrangement and moulding of the terraqueous surface, that they cannot possibly be overlooked by the geographical observer, either in his descriptions or in his determination of the laws upon which all geographical phenomena are dependent. Some idea of the magnitude of their combined influences may be formed by reflecting on the number of streams and rivers that are ever coursing over the earth's surface, and cutting out for themselves ravines, glens, and valleys ; on the extent of coast-line exposed to the degrading action of waves and tides and currents ; and on the areas in Iceland, Italy, Central Asia, Indian Archipelago, Philippine, Japan, and Aleutian Islands, Mexico, West Indies, Andes, and the Pacific islands (see Map of Volcanoes), that are subjected to earthquake and volcanic disturbance ; to say nothing of those areas like Scandinavia, Siberia, Arctic America, &c., that are undergoing the slower processes of gradual elevation or depression.

309. Notwithstanding these continual operations, their results, for any limited time, do not greatly affect the general relations of the earth ; and thus the geographer is enabled to depict, within appreciable limits, its existing aspects in an intelligible and available form. It is this intelligible account of existing appearances, and the causes concerned in their production, that constitutes the sum and substance of our science ; and just as this account is founded on correct observation and harmonises with sound induction, so the more rapidly will Physical Geography attain to perfection. As has been eloquently remarked by M. Guyot, " It is not enough for it coldly to *anatomise* the globe by merely taking cognisance of the arrangement of the various parts which compose

it; it must endeavour to seize those incessant mutual actions of the different portions of physical nature upon each other—of inorganic upon organised beings, upon man in particular, and upon the successive developments of human societies; in a word, studying the reciprocal action of all these forces, the perpetual play of which constitutes what may be called the Life of the Globe, it should, if I may venture to say so, take up its Physiology.” Understanding it in this light, the scheme of nature becomes invested with new interest, its various portions assume new harmony and unity, and man, in his physical, social, and moral development, stands in a clearer and closer relationship to the whole.

310. Bearing in mind the principles of the science as thus described, and the general laws by which the various domains of nature are held in cosmical harmony, we may now proceed to apply them in a brief explication of the respective continents or quarters of the globe which form the theatres of human action and enterprise. If the general principles are sound, they find their best illustration in the details of the minor sections, and, at all events, can be best understood in their applications to special instances. In this way a brief analysis of the respective continents may be useful to the general reader as well as to the student, and the law which was perhaps but slenderly understood may find more thorough comprehension by its application to particular instances that may come under the notice of the local observer. These minor sections are Europe, Asia, Africa, North America, South America, and Oceania—each presenting features and phenomena peculiarly its own, but all readily intelligible and in perfect harmony with the general principles laid down in the preceding chapters.

Continental Aspects—Europe.

311. Applying the principles laid down in the preceding chapters, we find that Europe lies almost wholly within the northern temperate zone, and, in consequence, will be mainly influenced in its climate, life, and industry by this great primary condition. Its limits are usually comprehended within the 36th and 71st degrees of N. latitude, and the 10th degree of W. and 64th of E. longitude; but its bounding line is rendered so irregular by the indentation of seas and gulfs, and the projection of peninsulas and promontories, that an idea of its configuration can be best obtained by a study of the Atlas. Its area, as already stated, is estimated at 3,725,000 square miles, of which about 317,500

belong to its islands and islets. Within this area there is every diversity (within ordinary limits) of surface ; and it is this diversity that confers on Europe its especial character as compared with any of the other continents. Devoid of immense plains like those of America, it is not marked by the same uniformity of vegetable and animal life that characterises the New World ; and wanting in those vast deserts and plateaux that occupy so much of Asia and Africa, it is not marked by those strong contrasts and separations that belong so peculiarly to the greater portion of the Old. Notwithstanding this diversity of surface, there is everywhere the most intimate connection, and thus it possesses a compactness—a unity in its variety, if we may so phrase it—that is not to be found in any of the other continental land-masses.

312. Notwithstanding this unity of conditions, it must be remembered that the mountain-systems of Europe (Chap. VI.) lying chiefly in the south, confer on its southern section an irregular and hilly aspect ; while the northern section, from the German Sea inwards through the Netherlands, Prussia, and Russia, is generally flat, or but little interrupted by elevations or depressions. We have thus a southern region characterised by its mountains, table-lands, and intervening valleys ; and a northern (Chap. VII.) marked by a predominance of pasture-plains, heathy wastes, lakes, and morasses. Unless in the extreme north, the greater proportion of the surface is more or less improved and under cultivation ; and though large tracts are still occupied by natural forest, heath, sandy waste, lake, and morass, yet, on the whole, the natural aspect of Europe has been much more modified by man than that of any other continent. In other words, the natural conditions of its soil and climate have been more interfered with by man's operations than those of any other region, and in a corresponding degree, also, the plants and animals by which it was originally peopled. It is the great headquarters of civilisation, commerce, and cultivation ; and thus, in all our reasonings on its geographical conditions, the modifying influence of man must be taken into account as an important and pervading element.

313. Geologically, Europe presents illustrations of every system, from the crystalline schists to the most recent alluvia, and from the deep-seated granites to the superficial dust of latest volcanic eruptions. From the broken and undulating nature of the country, these formations are irregularly brought to the surface in all the northern and western districts—northern and eastern Russia being the only region where formations are continuous over extensive areas. In this way the mineral and metallic treas-

ures of Europe become more readily available ; and these consist, in general terms, of granites, porphyries, marbles, limestones, coals, ironstones, gypsum, rock-salt, sulphur, sandstones, fire-clay, pottery-clays, alum-shales, sands, flints, and other mineral substances used in the arts and manufactures ; of iron, copper, tin, lead, silver, mercury, manganese, zinc, antimony, and other metallic ores ; of gold and platinum, though less profusely than in some other regions ; and of most of the precious or ornamental stones, with the exception of the diamond, Oriental ruby, and some varieties of the sapphire. This abundance and availability of the useful minerals and metals enabled her inhabitants to engage at an early period in arts, manufactures, and commerce ; and it is to this same abundance and availability that her present superiority in mechanical, manufacturing, and commercial industry is mainly attributable. From the absence of great rivers, and the paucity of volcanic centres, the existing geological relations of Europe are undergoing comparatively little change—the gradual uprise of the Scandinavian coast, the alluvial formations at the mouths of such rivers as the Po, Rhine, Danube, and Dnieper, and the alternate inroads and sand-silts of the Atlantic, being the only appreciable phenomena.

314. As might be expected from the position, configuration, and surface-diversity of Europe, its climate is also varied and variable, without participating in those violent contrasts which mark most of the other continents. Lying almost wholly within the northern temperate zone (only a fourteenth of its area being within the arctic circle), a very small portion is uninhabitable on account of cold, while even on its most southern limit the heat is by no means excessive. The mean temperature of its southern border is about 66 degrees ; and at Cape North, in lat. 71°, it is 32 degrees—a mean fully equal to what is experienced in North America between the parallels of 55° and 56°. On the whole, its mean temperature is higher than that of other regions within the same parallels, while in no part is it subjected to the same extremes of winter cold and summer heat. In fine, the climate of Europe partakes more of an *insular* than of a *continental* character ; and this arises mainly from the circumstance that she is surrounded on three sides by the sea, and otherwise indented by inland seas and gulfs, so that no extensive portion of her surface is far removed from the tempering influences of the ocean. Besides this, her western shores are laved by the current of the Gulf Stream, which not only brings an additional store of heat, but wards off the cold approach of the northern iceberg ; while the draining of marshes, clearing of forests, and other efforts of cultivation, have also tended

to improve the climatic character of the country. The fact, also, that the lower part of Europe lies towards the north and the higher to the south, is not without its influence in modifying the climate ; for had this been reversed—that is, had the Alps, Pyrenees, and Carpathians been situated in the north—more than a third of the surface would have been perpetually under snow and glacier, and the rest would have been periodically chilled by their proximity.

315. Arranging the surface of Europe into climatic zones, the three following regions are usually enumerated:—

1st, The *warm region*, where the lemon, orange, fig, olive, myrtle, and vine flourish, extending to the 45th degree of north latitude, and having a pleasant spring, a hot summer, and short mild winter. The countries within the belt have generally abundant rains during the last three months of the year, but are subject to great and long-continued droughts in summer.

2d, The *temperate region*, extending in the islands and seaboard to 55° north latitude, but in the interior perhaps not beyond 52°. In this region frost prevails two, three, or four months, and snow is common ; the spring continues from April till June ; the summer, the heats of which frequently rise to 92° Fahr., last till September ; and the autumn is the shortest season.

3d, The *cold region*, to the north, in which, beyond the 65th parallel, only two seasons occur—summer and winter ; the former lasting during June, July, and August, and the latter during the rest of the year. In this region the heat, during the brief summer, when the sun never sets, is very great, and the cold during the long winter proportionally severe—putting an end to all field operations, and closing the navigation of the rivers, friths, and seas.

316. In consequence of the principal mountain-chains being situated in the southern or warmer region, the climatic effects of altitude are less striking than in many other regions, though, as seen in Chap. XIII., the Alps and Pyrenees show various belts of vegetation, especially in their higher ridges. As the snow-line in Europe makes a very gentle curve from about 8500 feet in the Alps to 2000 feet at the North Cape, only very limited patches in the Alps and Dovrefelds come within its limit ; and hence, also, these are its only mountain-ranges that exhibit the phenomena of *glaciers*. As might be expected, the western side of Europe is the most humid, the number of wet days on the Atlantic seaboard averaging from 150 to 160 annually ; the southern or Mediterranean side is next in order, and averages from 90 to 100 days ; while in the centre and eastern districts a much smaller

proportion (from 60 to 80) is experienced. On the whole, the climate of Europe is variable, but not excessive—fickle, but not insalubrious ; calling forth the utmost skill and watchfulness on the part of the husbandman, but never wholly disappointing his hopes or defeating his labours.

317. Although biologists correctly regard it as forming merely the western portion of the great *Palæarctic* or Old World region, yet, as might be expected from this diversity of climate, as well as from the diversity of physical aspect formerly alluded to, the vegetation of Europe presents considerable variety and complication—a complication which is greatly enhanced by the long-continued introduction of plants, useful and ornamental, from other regions. Referring to Chap. XIII. for matters of mere botanical interest, we may here briefly enumerate the range and limits of those fruits and vegetables that have more especially a useful or economic bearing. The dwarf-palm, cactus, and banana are found skirting some of the warmer portions of the Mediterranean seaboard. From this point north to the 45th parallel, the orange, citron, fig, pomegranate, olive, almond, myrtle, laurel, cypress, mulberry, vine, &c., flourish in perfection—some of these, as the vine, being profitably cultivated in sheltered valleys, so far as the 50th degree. From the 45th to the 55th, the apple, pear, plum, cherry, apricot, and smaller garden-fruits are abundant ; and in the southern, middle, and western districts, as far north as the 60th parallel, the plane, chestnut, walnut, poplar, oak, ash, elm, beech, and other forest-trees, attain to perfect growth ; as do also wheat, barley, rye, oats, beans and peas, beet, carrot, turnip, and other bulbous roots, the potato, flax, and common cultivated grasses. In the central and eastern regions, where the climate is more decidedly *continental*, these plants find their limits at the 50th and 52d parallels, even in the lowest valleys. Forests of pine and birch continue in luxuriance as far as the 67th degree ; at the 70th, oats and barley are the only kinds of grain which resist the rigour of the climate, though not always ripening ; and beyond this the dwarf-birch and willow, the iceland and reindeer moss, constitute the principal flora.

318. From the densely-peopled and cultivated character of Europe, its fauna (in all the larger animals at least) may be regarded more as a domesticated than a natural one. The true natural fauna is varied enough in point of species, but not important in point of size or number, and, with the exception of those (the white bear, blue fox, reindeer, lemming, &c.,) restricted to its arctic section, can inhabit indifferently any part of the country. This moderate climate, and the absence of great moun-

tain and desert barriers, give a uniformity to the fauna of Europe which is not observable in other continents ; and this uniformity is greatly augmented by the circumstance that the larger and more destructive animals are all but extirpated. But while the moderate and equable conditions of Europe have been unfavourable to the preservation of the native fauna, they have been specially favourable to the spread and crossing of the domesticated—and thus improved and improving breeds are to be found in every portion of its surface. Devoid of the larger carnivora and reptiles, of the brilliantly-coloured birds and insects that belong to warmer latitudes, the continent of Europe preserves, in an eminent degree, the elements and facilities for the cultivation of the useful and agreeable. In this way, partly from native and partly from exotic stocks, have risen the many and valuable varieties of the horse, ass, ox, sheep, goat, and pig ; of poultry—peacock, turkey, guinea-fowl, barn-fowl, swan, goose, duck, pigeon, &c. ; and in a less degree also of game birds, such as the grouse, ptarmigan, partridge, capercailzie, and pheasant. In this way, too, the temperate seas of Europe are stocked with inexhaustible supplies of wholesome fish, shell-fish, and crustacea, of which the cod, ling, tusk, haddock, turbot, sole, skate, salmon, sturgeon, tunny, herring, pilchard, mackerel, crab, lobster, prawn, shrimp, oyster, cockle, mussel, and periwinkle, are among the most abundant and valuable.

319. On the whole, the geographical conditions of Europe,—its varied surface, numerous seas, and extensive sea-coast—its climate, mineral, vegetable, and animal productions,—eminently fit it for developing the enterprise and industry of its inhabitants. And this development has been further fostered by the fact that all the finer southern and western portions are peopled by the more energetic Indo-European or Caucasian race, while the eastern and northern (or least valuable sections) are inhabited by families of Mongolian descent. Into the numerous families and tongues which time and the influence of external conditions have evolved from these two races, our limits will not permit us to enter ; but it may be remarked that the Teutonic, Slavonian, and Celtic are the predominating sub-varieties—each embracing a vast number of minor nationalities and tongues, which are still acting and reacting upon each other in production of newer, and, on the whole, advancing stocks. The causes that regulate the growth and decay of nationalities is yet imperfectly understood ; but however much may be ascribed to the inherent physiological peculiarities of race, there can be no doubt a vast amount depends upon the geographical or physical conditions of situation. In this respect the in-

habitants of southern, central, and western Europe have had important advantages; and hence their superior civilisation, their progress in the arts and manufactures and in all that relates to mechanical and commercial industry; and as a secondary consequence, also, their spread over a large portion of the New World and Australasia, whose aboriginal races seem destined to disappear before them.

Asia.

320. This anciently-peopled continent is by far the most extensive and diversified, the most compact in point of configuration, and yet, paradoxical as it may seem, the most widely separated in the character of its parts of any of the so-called "quarters" of the globe. Situated between lat. $1^{\circ} 28'$ and 78° north, and long. 26° and 190° east, it occupies the greater portion of the eastern hemisphere, and presents an area estimated at 16,165,000 square miles, or more than four times that of Europe. A considerable portion of this is insular and peninsular, but not to such an extent as to interfere materially with the massiveness and continuity of configuration to which we have referred. Occupying three great climatic belts—tropical, temperate, and arctic—and exhibiting vast mountain-chains and lofty table-lands, broad grassy steppes and shingly deserts, luxuriant river-plains and tracts doomed to everlasting snow or scorching sterility, it is impossible to treat the continent as a whole, and hence it is usual to arrange it into northern, central, western, eastern, and southern sections—each having well-marked and distinctive features.

321. 1st, Northern or Russian Asia includes the whole of the continent north of the Altai and Yablonnoi Mountains—a region (as we descend from the mountains) of rocks and forest-growth, steppe-land and frozen tundra, bleak and barren, suffering from intense cold, thinly peopled, and almost physically incapable of improvement. Steppes affording a rough pasture in summer, and here and there capable of a rude cultivation; forests of pine and birch, gradually dwarfing to the north and east; and tundra or bog-moss frozen for ten months a-year, and scarcely thawed to a foot in depth during a brief summer, are the leading features of this inhospitable section.

2d, Central Asia, lying principally between the 30th and 50th parallels, embraces the lofty table-lands of Gobi, Mongolia, Tibet, and Eastern Tartary—a region of sandy deserts and salt lakes, diversified by mountain-knots that rise above the snow-line, and occasionally intersected by narrow valleys of considerable amenity.

As the northern section was the region of frozen, so the central is the region of arid deserts, with this difference, that the more southerly position of the latter confers on its deeper valleys both verdure and fertility.

3d, Western Asia, still exhibiting a series of plateaux, and partaking of the desert character of the central region, but less elevated and more broken up by hill-ranges and intervening valleys. On the whole, it is a hot and thirsty region, consisting largely of high sandy plains studded with numerous salt lakes, and but inadequately watered by rivers. The steppes of Western Tartary, the table-lands of Persia, and the deserts of Arabia, belong to this region—the finest portions being Turkey in Asia, Georgia, and the plains of the Tigris and Euphrates.

4th, Eastern Asia, or that embracing the Chinese Empire, Mandshuria, and the Islands of Japan, is one of the finest and most diversified sections of the great continent. The mountains of China and Mandshuria give to its western and northern portions an irregular and varied aspect, but its eastern consists of the great Chinese plain and low-lying region of vast extent and fertility.

5th, Southern Asia, including Hindostan, Farther India, and the Malayan peninsula, and lying largely within the tropics, is decidedly the richest and most diversified region of the whole. Varied by minor hill-ranges and well-watered valleys, by deltas and river-plains, it enjoys a high though not oppressive temperature, has only a rainy season for its winter, and, except during long droughts in Central Hindostan, presents in every district an unfailling verdure.

322. The geological features of regions so vast and varied must necessarily partake of corresponding diversity ; and though the geology of Asia is but imperfectly known, we have gathered enough from recent surveys and travels to confirm the belief that every formation is there displayed, and this frequently on a most gigantic scale. Partaking of the arctic uprise of land in Siberia, having large rivers with gradually increasing deltas like those of the Indus, Ganges, and rivers of China, and being subjected in a remarkable degree to volcanic and earthquake disturbance in almost all its islands, as well as in several parts of the mainland, its geological relations must be undergoing considerable modification, but not at such a rate as to interfere, for generations, perhaps, with its general features. All the economic minerals and metals are found within one or other of its countries ; the precious metals and gems also occur in abundance ; and though less noted for its coal and iron than Europe or North America, it has still enough, in India, the Indian Archipelago, China, and Japan, to

form the basis of a successful mechanical and manufacturing industry.

323. A continent stretching over three great geographical zones—tropical, temperate, and arctic—must necessarily exhibit great diversity of climate; and this diversity is rendered still more remarkable by the lofty table-lands, arid deserts, and snow-clad mountain-masses that occupy so large a proportion of the central regions. On the whole, as we have elsewhere observed, the continent of Asia does not enjoy the same modifying and tempering influences as Europe. A large proportion is situated on the confines of the polar circle, where, according to Von Wrangel, the winter's ice is gradually accumulating and overmastering the summer's heat; a still larger section is raised to an enormous altitude, and placed permanently under snow and glacier; its mass lies comparatively unbroken by intersecting and tempering seas; it has no burning sandy tracts in the south to send warm breezes, as the Sahara does to Europe; the Japan Current, whose genial waters lave its eastern coast, is of minor volume compared with the Gulf Stream; and even its southern or tropical districts are cooled by the winds that flow from the snow-clad central mountains. It suffers, therefore, what Humboldt calls an *excessive* climate—that is, excessively hot in summer and excessively cold in winter, or differing greatly during these seasons from the mean annual temperature. In other words, while the climate of Europe is more insular than continental, that of Asia is strictly and emphatically continental. As instances of its extremes, it has been remarked that grapes come to maturity on the borders of the Caspian, and yet the thermometer falls there in winter to 28° Fahr.; that at Tara, in Siberia, the temperature of the air in July and August rises to 82°, while a foot under the surface the soil remains permanently frozen; that in Arabia, after a night of hoarfrost, the day-heat will often be as high as 114° Fahr.; that the snow-line in the Elburz is found at 11,000 feet, while in Tibet the mountains are clear at an elevation of 16,000 feet; and that while all the great central deserts are all but rainless, the annual rainfall in the lower plains of India amounts to 400 or 500 inches.

324. Asia includes the larger portion of the *Palæarctic* region of biologists, and the northern half of the *Indian* or *Oriental* region. With a position so extensive, a contour so decided, and a climate so varied, we might naturally expect an abundant and diversified life, and in this respect, both vegetable and animal, it stands unrivalled among the other continents. If excelled in vegetable luxuriance by tropical America, it has at least greater variety of forms, while its animal life has a physiological power

and completeness unapproached by that of other regions. Referring to Chap. XIII. for the general features of its vegetation, as governed by the great climatic zones, we shall here merely allude to those products which, like tea, are either peculiar to its soil, or which, from their value, are of industrial and commercial importance. Among its *fruits* may be mentioned the grape, orange, shaddock, lemon, lime, tamarind, mangosteen, fig, mulberry, olive, pomegranate, walnut, almond, cocoa, date, bread-fruit, cashew, betel, banana, pine-apple, melon, quince, apricot, peach, and all the garden-fruits known in Europe; among *grains* and cultivated *roots*—maize, rice, wheat, dhourra, barley, peas, beans, lentils, and other leguminous seeds, potato, yam, lotus, arrow-root, &c.; among *spices* and kindred products—cinnamon, nutmeg, clove, pepper, camphor, cassava, tea, coffee, sugar, sago, &c.; among *drugs, dye-stuffs, fibres*, and the like—indigo, arnatto, saffron, cinchona, gamboge, galls, poppy, rhubarb, aloes, gums, hemp, jute, cotton, and many others; while among the *forest* and *ornamental trees* may be noticed the teak, cedar, sycamore, cypress, savin, mangrove, bamboo, banyan, plantain, cocoa and other palms, along with ebony, iron-wood, box-wood, sandal-wood, and others of a kindred nature.

325. It has been remarked by Guyot, that “as in the New World the vegetable kingdom has the preponderance over the animal, so in the Old World the animal has the preponderance over the vegetable. Not only are the representatives of the corresponding families larger and stronger in the Old World, but they appear in more numerous genera and more varied species, and even exhibit types entirely foreign to the New.” In accordance with this opinion, it might naturally be expected that Asia, the largest and most diversified of the Old World continents, should have a fauna of corresponding variety and power; and thus it is that in all the zoological classes (with the exception, perhaps, of the reptiles and insects which dominate in tropical America) its animals excel both in nobleness of form and in numbers. Among the *mammalia* may be noticed the apes and monkeys of the south; the lion, tiger, leopard, panther, ounce, and other felinæ of the south and west; the elephant, rhinoceros, and tapir of India; the wolf, hyena, jackal, blue and black fox, and numerous varieties of dog; the horse, ass, dzigettai, and camel of the central and western plains; the common ox, buffalo, auroch, yak, and musk-ox; the elk, reindeer, antelope, axis, argali, ibex, goat, sheep, mutton, &c.; porcupine, jerboa, marmot, lemming, beaver, bat, ermine, &c.; together with bears, badgers, gluttons, sea-otters, seals, sea-cow, and other cetacea. As her *mammalia* excel in variety, so also they excel in

utility ; and from Asia, as the original source, have other regions derived most of their domesticated and semi-domesticated animals, as the horse, ass, camel, elephant, ox, goat, sheep, pig, dog, cat ; peacock, pheasant, barn-fowl, and other creatures so necessary to the comfort and luxury of civilised communities. Her seas, lakes, and rivers are stocked with valuable food-fishes, though less notably than Europe ; red-coral, mother-of-pearl, and pearls are fished from her gulfs ; and among her special insect-products may be noted her silk, honey, bees-wax, cochineal, gall-nuts, lac, and other kindred substances.

326. Ethnologically the continent of Asia is occupied by three main varieties of mankind—the Caucasian, Mongolian, and Malay ; the first inhabiting the south and west, the second the north and east, and the third the south-western region and adjacent Archipelago. Though each of these varieties embraces a vast variety of families and tongues—Hindoos, Persians, Syrians, Arah ; Chinese, Japanese, Mongols, Tartars ; Burmese, Javanese, Polyne-sians—yet, on the whole, the physical peculiarities of the continent have kept them wonderfully apart, and thus each has enjoyed its own peculiar civilisation for ages. How little has China and Japan been influenced by India ; how little has the civilisation of Japan reflected on Malaysia ; and though Tartar and Kalmuck inroads from the north have been frequent enough on the south, how little impression, save that of destruction, have they left on the plains of Persia or the deserts of Arabia ! Mountains and deserts form barriers more impassable than seas ; and thus, altogether apart from the physiological peculiarities of the Mongolian and Malay races, there has been none of that action and reaction, that domination and absorption, that commingling and evolution of higher stocks, that has marked the progress of mankind across the continent and along the seaboard of Europe. The civilisations of Europe have been more maritime than continental ; those of Asia more continental than maritime. The one, in minor areas and along varied seaboard, has had a tendency to develop social and complex relations ; the other, in vast areas, and chiefly on far-separated river-plains, has been more productive of isolation and stationary individualism. “What has been wanting to the communities of Asia,” it has been well remarked, “is the possibility of actions and reactions upon each other, more intimate, more permanent ; it is the possibility of a common life. On the other hand, the smallness of the area, the near neighbourhood, the mid-land seas thick sown with islands, the permeability of the entire continent—everything conspires to establish between the European nations that community of life and of civilisation which

forms one of the most essential and precious characteristics of their social state." It is thus that civilisation in Asia stands still or declines, while in Europe it is ever active and progressive.

Africa.

327. The next great "quarter" of the Old World is that of Africa, having an estimated area of 11,360,000 square miles, or, including Madagascar and the other islands, of 11,855,000. It lies between the parallels of 37° N. and $34^{\circ} 50'$ S., and between long. $17^{\circ} 30'$ W. and $51^{\circ} 30'$ E.; being thus mainly tropical, and having only its northern and southern borders within warm-temperate latitudes. Separated from Europe by the Mediterranean, and but slenderly united to Asia by the low Isthmus of Suez, which is only 72 miles across, it is all but insular, and has consequently little of that community which marks the relations of Europe and Asia. The continuity of its coast-line is almost unbroken by seas, gulfs, or estuaries, and this resisting solidity of form is no doubt the chief cause of its interior being less known than that of any of the other continents. Even the disposition of its rivers is unfavourable to its penetration. The largest of them flow within its equatorial limits, and either debouch through swampy jungles, which is death for the white men to enter, or descend by cataracts and waterfalls inaccessible to navigation.

328. So far as we know the physical peculiarities of the continent, it may be divided into four or five regions—differing more in physical structure, but less in climate and vital aspects, than the regions of any of the other continents. Beginning with the north, we have—1st, The mountainous district of the Tell lying between the Mediterranean and the Sahara, and composed largely of the Atlas chain, with its subordinate spurs and intervening valleys. Where the hills decline towards the Atlantic in Marocco the district is somewhat flat, but, generally speaking, it is hilly and irregular, with a warm but salubrious climate towards the Mediterranean, and a dry scorching one on the north, where it insensibly graduates into the Sahara.

2d, The region of the Sahara or Great Desert, which stretches from Marocco on the west to the Nile Valley on the east—a hot and arid expanse, consisting partly of shingly plateaux resting on gypsum and largely impregnated with salt, and partly of dunes or ridges of drifting sand, the whole being marked at intervals by *oases* or fertile spots that enjoy the presence of a spring or runnel of water. The Sahara has thus its fertile and inhabited oases, its

scrubby plateaux, and its shifting dunes of utter sterility. Its general character, however, is aridity and barrenness, and the oases merely appear like islets of verdure amid an ocean of desert.

3d, The Atlantic-coast region, a belt of luxuriant but unhealthy lowland, marked by numerous deltas and jungles along shore, but gradually rising and improving towards the interior. This region is rich in tropical forest-growth and verdure, but its pestilential climate has hitherto resisted all European approach, unless at a few very limited and unsatisfactory stations.

4th, The Southern or Cape region, which rises by successive hill-stages towards the north or unknown interior—these stages forming irregular terraces which are covered with grass after the rains, but become hard and bare, or but partially dotted with thorny scrub, during seasons of drought. On the whole, this region is hilly and irregular in surface, has a salubrious but arid climate, is by no means well watered by rivers, and is occasionally subject to destructive droughts. In the Natal district, having a mean temperature of 65° , the climate is more genial—the rainfall during the wet season, which continues from October till the end of March, amounting to 36 or 38 inches, though during the dry season it seldom exceeds a couple of inches.

5th, The Central region, which, so far as we can judge from recent discovery, partakes of the character of a high table-land, having numerous permanent wide and deep lakes; but is wanting, on the whole, in rivers of permanent volume and navigable channels. Though strictly tropical, the elevation of this table-land confers on many portions the climate of temperate zones; and where water is present the country is described as fine and fertile, well peopled, and partially under a rude cultivation.

The 6th and last region is that skirting the Red Sea, and comprising the hilly but not unfertile table-land of the Galles and Abyssinians, the more stony and arid country of Nubia, and the alluvial valley and delta of Egypt. This region is remarkable for its fine but somewhat arid climate; its fertility where water is present; and, ethnologically, for the early and peculiar character of its civilisation.

329. Geologically, we know little of the formations of Africa, and hitherto the continent has contributed less to the mineral and metallic wealth of the civilised world than any other region. The whole of the Sahara is but the upheaved bed of a tertiary, or even quaternary ocean; the deltas of the Nile, Niger, and other great rivers, consist of recent alluvia; the formations of the Cape are chiefly mesozoic sandstones and diamond-yielding drifts;

Natal has an available but limited coalfield ; the northern belt consists largely of soft tertiary limestone ; the primary hills of Abyssinia and Nubia are known chiefly for their granites and porphyries ; and most of the islands, whether in the Atlantic or Indian Ocean, are of recent volcanic origin. The great interior is unknown, but, judging from conformation as well as from native ornaments and report, iron, copper, gold, and silver must exist in its mountains.

330. As already observed, the greater portion of the continent lies within the tropics, and must necessarily partake of the climate peculiar to the torrid zone. The Cape region and the region of the Tell are the only parts enjoying warm-temperate or sub-tropical conditions, and even these are more or less influenced by the excessive climate that pervades the interior. "It is only that strip of Barbary," says Balbi, "which the Atlas protects from the hot winds of the desert, and that part of Hottentotland protected by the Nieuveltdt and the other mountains near the Cape, that enjoy the advantages of countries situated within the temperate zones. With the exception, therefore, of these small and narrow tracts, of those regions in the interior to which their elevation imparts the coolness of higher latitudes, and of the borders of the great lakes and rivers, much of northern and central Africa is burnt up by continual heat, and the continent generally may be regarded as the warmest region of the globe. Nothing moderates the heat and the dryness but the annual rains, the sea-winds, and the elevation of the soil ; while in the well-watered regions, the moisture combined with the heat, though productive of the most luxuriant vegetation, is extremely deleterious to man."

331. Africa includes the whole of the *Ethiopian* region of biologists, together with a large portion of the *Palæarctic* region—the two being separated by the barren waste of the Sahara. As might be expected from the tropical position and generally hot and arid climate of Africa, its vegetation is more unique and much less varied than that of Europe or Asia. Along the Mediterranean seaboard and the lower valley of the Nile, the vegetation greatly resembles that of southern Europe, with a greater tendency, perhaps, to tropical forms. Wherever soil and water can be obtained, rice, maize, wheat, lentil, and millet ; the grape, orange, fig, olive, and date ; cotton, flax, and tobacco,—can be grown to perfection, and often, as in lower Egypt, yield large returns. The Sahara, where vegetation is possible, is characterised by its prickly shrubs, brooms, pistachios, tamarisks, ephedras, and dry tufty stypa grass ; while in its oases the date-palm is the indispensable product, having, as the Arabs say, "its feet in water

and its head in fire." In Upper Egypt and the highlands of Nubia and Abyssinia, the characteristic plants are gum-yielding acacias, the cassia or senna shrub, coffee, ginger, turmeric, cardamoms, melon, lotus or jujub, the nelumbium or water-lily; and the cultivated ones, maize, lentil, and millet. The Cape region, as might be expected from its arid soil and climate, is distinguished for its heaths, proteas, pelargoniums, mesembryanthemums, stapelias, crassulas, euphorbias, aloes, cactuses, thorn-apple, mimosa, and prickly shrubs; and at the same time yields profitably such plants as have been introduced by the settlers, as vines, currant-grape, orange, pine-apple, peaches, apricots, pears, apples, and other garden fruits; together with rice, cotton, tobacco, tea, and coffee. In the central parts of the continent, the vegetation, of course, is strictly tropical—palms of many species, banyan, Adansonia, banana, dragon-tree, papaw, tamarind, sugar-cane, cotton-tree, tallow-tree, maize, manioc, yam, ground-nut, melon, and the like, being the native produce; while in the islands (Mauritius, Madeira, &c.), the vine, lemon, orange, melon, coffee, and sugar-cane can be grown to perfection.

332. Like the other continents of the Old World, Africa possesses a numerous and diversified fauna, though from its greater uniformity of climate, its almost insular position, and the absence of vast intervening barriers, there is a greater sameness or community between its different regions. It has also several forms peculiar to itself, though, remarkable enough, these forms are found fossil in the more recent tertiaries of Europe and Asia. The tropical forests abound in apes, monkeys, and baboons; the larger felinæ (lion, panther, leopard, &c.) roam almost from one end to the other of the continent, as do also the hyena, jackal, and their congeners; antelopes, in numerous species, are nowhere so abundant; it possesses also, in a special degree, the Cape buffalo, camel, dromedary, giraffe; the horse, zebra, dauw, quagga; the elephant, rhinoceros, hippopotamus, and species of river-hog; cetacea (whales, seals, dolphins) are all but unknown in its waters, but many of the smaller mammals, hyrax, porcupine, ant-eater, pangolin, jerboa, &c., are peculiar and numerous. Among the birds of Africa may be mentioned eagles, griffins, vultures, and other birds of prey; ostrich, bustard, guinea-fowl, quail; flamingo, pelican, secretary-bird, crane, ibis; parrots, parroquets, and others of brilliant plumage; cuckoo, swallow, nightingale, canary, and the like, which are only known to us as summer visitants or household captives. Though numbering among her reptiles, turtles, crocodiles, monitors, lizards, chameleons, &c., Africa, as a tropical country, is by no means rich in serpents; and though

her seas and rivers abound in fish, yet in food-fishes she falls far behind the sister-continents of Europe and Asia. Her insects, too (locust, white-ant, scorpion, tsetze-fly, &c.), are chiefly destructive or troublesome; and she possesses few or none, like the silk-worm, cochineal insect, and bee, of commercial utility.

333. The inhabitants of Africa (laying aside English, Dutch, Portuguese, and other European settlers) belong chiefly to the Semitic branch of the Caucasian variety in the north, and wholly to the Negro or Ethiopian variety in the central and southern regions. The Semitic or Syro-Arabian stock embraces the Egyptians or Copts, the Abyssinians, Nubians, Arabs, Berbers, Moors, and other families arising from their admixture; the Negro variety embraces, on the other hand, the whole of the dark-coloured races—Gallas, Fellatah, Jalofes, Mandingoes, Krus, Ashantees, Congos, Zulus, Kaffirs, Hottentots, Bosjesmen, &c.—that people the continent from the Sahara to the Cape. Unless within the European settlements, civilisation in Africa is at a very low ebb. The Moors and Arabs, though active traders, are but in a state of semi-civilisation: their manufactures in silk, cotton, linen, leather, and the like, are rude; and their commerce, carried on chiefly by caravan, is limited and uncertain. The Negro races, on the other hand—though some tribes indulge in barter, others keep herds, and some again attempt a primitive agriculture—are not, as a whole, raised beyond the level of barbarism. The inherent qualities of the race are evidently inferior; and whether it is capable of amalgamating with the white, of being taught and elevated by its example, or is doomed ultimately to disappear before it, are problems yet to be solved by the ethnologist. On the whole, the habitat of the true Negro seems to be strictly intertropical; under its fiery sun he is robust, hardy, and lively; beyond it he becomes enfeebled, and degenerates. The heat, however, that develops the Negro enervates the white, and this circumstance may yet reserve for the former an equatorial zone in which it may attain to a limited and semi-dependent civilisation.

North America.

334. This great section of the New World bears much the same relation to the western hemisphere that Asia-Europe does to the eastern; while South America holds a somewhat analogous position to Africa. Like Europe and Asia, North America lies chiefly within the northern temperate zone; has its coast-line well diversified by bays, gulfs, peninsulas, and promontories, and has also numerous outlying islands. South America, on the other hand,

lies, like Africa, mainly within the tropics; is also slenderly united to the North by a narrow peninsula; has a coast-line little broken by indentations; and has, in like manner, fewer and less important islands. Unlike the Old World, however, the trend of whose main mountain-masses are latitudinal, the New World has its mountain-chains arranged longitudinally; and this disposition confers, of course, on its surface many important distinctions, both physical and vital. On the whole, the continent of North America enjoys temperate position, extent of coast-line, and ready access to its interior by bays, lakes, and rivers.

335. Physically, the continent may be arranged into the following regions, the nature of which, with slight modifications, are thus given by Malte Brun and Balbi:—

1st, The narrow region of Central America, which lies between the Gulf of Mexico and the Pacific, and is traversed throughout its whole length by mountain-ranges, which leave but a strip of low land along the sea-coasts, while in certain portions of the interior they form elevated table-lands. This region is strictly intertropical, and, along with the West India Islands, is marked by a tropical flora and fauna, unless in the more elevated portions of the interior.

2d, The west maritime region, extending from the extremity of the Californian peninsula northwards to Alaska, and from the shores of the Pacific inland to the ridge of the Sea Alps. This region has a fair climate, but is hilly, irregular, and cut up by numerous cross-gorges from the mountains.

3d, The elevated region which forms a sort of table-land between the Sea Alps on the west and the Rocky Mountains on the east. In its southern portion it presents the arid salt plains of the Californian desert; between 40° and 45° north it presents alternate patches of wood and desert; but beyond the last-mentioned parallel it becomes largely forest-clad.

4th, The great central plain of the Missouri and Mississippi, and the rugged cañon region of Colorado, extending from the Rocky Mountains on the west to the Alleghanies on the east, and from the Gulf of Mexico northward to the 50th parallel. On the east this region is rich and well wooded; in the middle it is open or rolling prairie-ground, rapidly developing into a rich agricultural region; but near the foot of the Rocky Mountains it is dry, sandy, and almost a desert.

5th, The eastern declivities of the Alleghany Mountains and the maritime region, extending to the shores of the Atlantic. This is a region of natural forests, of mixed but rather poor soil, and with considerable tracts of swamp-land in the south.

6th, The great northern plain beyond the parallel of 50° , over-spread on its southern limits by pine-forests, but beyond this, for four-fifths of its area, a bleak and desolate waste, overspread with numerous lakes, and resembling Siberia in the physical character of its surface and the rigour of its climate.

7th, To these may be added (though not belonging to the American continent) the frozen region of Greenland and the Arctic islands—a division of the globe doomed to perpetual snow, ice, and glacier, and whose wealth arises more from the temporarily open seas that surround it, than from the land of which it is composed.

336. Geologically, this continent presents every stratified formation, from the old crystalline schists of St Lawrence and the Appalachians down to the recent alluvia of the Mississippi, and from the granites, syenites, and porphyries of the Rocky Mountains down to the recent ejections of the Mexican volcanoes. The great central plain, from the delta of the Mississippi north to the source of the river, is chiefly of recent origin, and consequently yields comparatively few mineral or metallic treasures ; but in the other regions the economic minerals are numerous and abundant. Of these may be mentioned—granite, and building-stones of every description ; limestone, marble, magnesian limestone, and gypsum ; salt and salt-springs in great abundance, and from several formations ; coal, both anthracitic and bituminous, in inexhaustible fields in the United States and Nova Scotia ; asphalt, pitch, and petroleum springs ; roofing-slate, whet-slate, and other minor minerals. The chief metals are—gold in California, British Columbia, Mexico, and the Carolinas ; silver in the Central States, Nevada, and Mexico ; iron in the United States, Canada, Mexico, and other districts ; copper abundantly in the United States, Canada, and the far north ; lead also abundantly in the Western States and Canada ; and tin, mercury, and antimony in Mexico and California.

337. As will be seen by a glance at the sketch-map of isotherms, the climate of North America is greatly inferior to that of the Old World within corresponding parallels of latitude. The great extent of surface that lies within the arctic zone, the solidity of its mass, unbroken by the tempering influence of seas, the flow of the arctic current that chills so much of its eastern seaboard, the amount of forest and undrained lands, and the cold aerial currents that pass from the frozen lake region of the north over the interior, all conspire to diminish the temperature that normally belongs to its geographical position. This diminution is usually stated to be about 10° Fahr., as compared with the temperature

of the same parallels in the west of Europe. The western or Pacific seaboard, however, is much warmer than the eastern on the same parallel; but this influence is little felt beyond the ridges of the Sea Alps, and does not tend to mitigate the northern air-currents that reduce the temperature of the interior. Altogether, North America possesses a true continental climate—severe winters and warm summers; and from this circumstance it has been supposed that it will be impossible to carry the arts of civilised life much beyond the 56th or 58th parallel—latitudes beyond which are situated the capitals of Norway, Sweden, and Russia.

338. The boundaries of North America agree almost exactly with those of the *Nearctic* region of biologists, and compared with the Old World, the New World excels in the exuberance of its vegetation. The breadth of its plains, the humidity of its atmosphere, and its rich and well-watered soil, confer on it a verdure—a “leafiness,” as it has been termed—not to be found in the flora of the old. From the Isthmus of Panama north to the 27th parallel, the vegetation (with the exception of that on the higher table-lands) is altogether tropical; and hence all the low grounds of the West India Islands and Central States teem with the products of that zone.* From the 27th north to the 35th parallel is the warm-temperate zone of the continent, marked by its magnolias, swamp-hickories, lobelias, deciduous cypresses, and luxuriant climbers and aquatics; and between the 35th and 44th parallels may be said to lie the true temperate zone, characterised by its oaks, ash, hickory, plane, white cedar, sassafras, cornel, yellow birch, red maple, fine flowering climbers and aquatics, and growing in perfection all the cultivated fruits and grains. North of the 44th parallel to the basin of the St Lawrence and Canadian lakes stretches the colder-temperate zone, with its oaks, elms, birches, maples, red and white pines, and the ordinary fruits and grains of temperate Europe; while northward and beyond lie forests of pine and fir, that gradually give place to the dwarf

* “The rich and varied productions of the West Indies,” says a recent authority, “give them an important place in the commercial world. To their valuable native plants, art and industry have added others not less valuable. The sugar-cane, yielding its threefold tribute of sugar, molasses, and rum; the coffee-plant, pimento, or allspice; the plantain and the banana; the pine-apple, anona, yam, sweet-potato, maize, cassava, manioc, with cacao, tobacco, and cotton; various dye-woods and stuffs, as fustic, logwood, indigo; medicinal plants, as liquorice, arrow-root, ginger, jalap, ipecacuanha; building and cabinet timber, as mahogany, lignum vitæ, and cedar; to which list may be added the bread-fruit, cocoa, mango, papaw, guava, orange, lemon, tamarind, fig, and other tropical fruits.”

willows and birches of the arctic regions. In an economic or agricultural point of view, it may be stated that all the common garden-fruits of Europe can be reared in the northern States of the American Union ; while oranges, pomegranates, melons, figs, peaches, grapes, olives, almonds, &c., can be grown in the south. Indian corn is cultivated all south of Maine, tobacco as far north as 40°, cotton to 37°, the sugar-cane to 32°, rice in the Gulf States, wheat all over the Union, oats and rye chiefly in the north, and hemp, flax, and hops in the western and middle districts.

339. It has been already stated that while the New World excels in the exuberance of its vegetable forms, it falls far behind the Old in the variety and importance of its animals, the reptiles and insects alone excepted. Many of the higher forms are altogether wanting, others are but feebly represented ; while, generally speaking, there is a greater paucity of specific variety even in the forms that occur. Whatever may have been the condition of the New World during geological times, it is certain that since the current era it had no native horse, ass, zebra, or other equine species ; no giraffe, camel, or dromedary ; no elephant, hippopotamus, or rhinoceros ; no useful ruminants comparable to those of Europe and Asia ; and though the puma, jaguar, and ocelot may represent the lion, tiger, and leopard, there is a feebleness and want of numerical abundance even in these, as compared with feline and carnivorous animals of Asia and Africa. Besides these, other Old World forms have their representatives, but still inferior in power and numbers—as, for example, the camel by the llama, the marsupials of Australia by the opossums, the ostrich by the rhea, the crocodile by the alligator, and so on of other orders. In like manner the monkeys of the New World are inferior to those of the Old ; the native red man also is less robust, less hardy, and less lively than the black man of the Old ; and thus, while the latter has thriven and multiplied even under toil and oppression in the New, her own aborigines have dwindled and died at the sight of industry and application. From the proximity of the continents, perhaps, there is a stronger resemblance between the fauna of North America and that of Asia-Europe than there is between those of South America and Africa, though both are chiefly tropical ; and hence such forms in the north as the Esquimaux dog, the lynx, wolf, fox ; polar, black, and grizzly bears ; badger, otter, beaver, ermine, bison, elk, reindeer, moose, red, and other deer. It is chiefly from this cause that all the domestic animals of the Old World—horse, ass, camel, ox, sheep, goat, pig, dog, cat, poultry, and the like—have been introduced with such

success in North America, and have spread with the colonists over every habitable region of the continent.

340. Referring to Chap. XV. for the characteristics of the aborigines of the New World—the American or red variety of mankind—we may here remark that at the time of its discovery in 1492, North America was inhabited chiefly by *Indian* tribes, who led a savage life, and obtained their subsistence by hunting and fishing, having neither herds nor flocks, nor even attempting the rudest forms of agriculture; by the *Aztecs*, a civilised offshoot of the race who inhabited the Mexican table-land, and had made considerable progress in the arts; and by the *Esquimaux* (of Mongolian descent), who peopled, as they do now, the shores of the northern seas, and subsist wholly by fishing. Since then the continent has been colonised and peopled principally by Europeans (we exclude the African negroes imported as slaves, and their half-breed progeny), Spaniards in Mexico and the West Indies, French along the St Lawrence and Mississippi, British, Dutch, and Germans originally along the eastern seaboard, but now over the whole habitable surface of the central areas. From these, and from their admixtures, have arisen what may be termed the Anglo-American family, before whose advance the native tribes are rapidly disappearing, and who, carrying with them and still enjoying all the advantages of European civilisation, are gradually laying the foundation for newer phases of progress, in conformity with the special conditions of their continent. We say *phases*, for the continent seems too large, and its geographical conditions and consequent industry too diversified, ever to be governed by a single and uniform rule.

South America.

341. United to North America by the narrow Isthmus of Panama, which is little more than eighteen miles across, South America, like Africa, stretches away into the southern hemisphere, bulking broadly beneath the equator, but gradually tapering till it terminates in the bold rocky promontory of Cape Horn. Extending from lat. 12° north to 56° south, and from long. 25° to 82° west, it has an estimated area of 6,820,000 square miles, fully two-thirds of which are situated within the tropics. Like Africa, its triangular outline is little broken by gulfs or bays; but, unlike that continent, it has a gigantic river-system, whose estuaries and channels afford the means of communication with its remotest interior. All its better portions are thus fairly accessible—the

only barrier being the lofty ridges of the Andes (practicable only at a few narrow passes), which separate the eastern plains from the western seaboard. If we except the West Indies, which have been noticed in connection with North America, it has few contiguous islands, and these are comparatively small and of little importance.

342. In physical aspect the continent has been arranged by the authors of the 'New York Atlas' into the following regions:—

1st, The low-terraced belt of country skirting the shores of the Pacific, from 50 to 150 miles in breadth and 4000 in length, of which the two extremities are fertile, and the middle sandy, arid, and dotted with *salinas*.

2d, The basin of the Orinoco, enclosed by two divergent branches of the Andes, and consisting of extensive plains, called *llanos*, either destitute of wood or merely dotted with trees, but covered during part of the year (the rainy season) with luxuriant herbage.

3d, The basin of the Amazon, a vast plain, embracing a surface of more than 2,000,000 square miles, intersected by numerous tributary rivers, possessing a rich soil and humid climate, almost entirely covered with dense forests (*selvas*) and impenetrable jungle-marshes by the river-sides.

4th, The great valley of the Plata, occupied chiefly by open plains called *pampas*, in some parts (towards the Andes) barren and shingly, but in general covered with weeds, thistles, and tall grasses, on which feed prodigious herds of wild horses and cattle.

5th, The high country of Brazil, eastwards of the Paraña and Uruguay; presenting alternate ridges (*sierras*) and valleys covered with wood towards the Atlantic, but opening into *steppes* in the interior.

6th, The sterile region of Patagonia, rising by successive stages from the Atlantic—the soil shingly and strewn with boulders, the grass stunted, and the climate cold and tempestuous.

And, lastly, the Andean belt, stretching from south to north, consisting of mountain-ridges covered with snow and volcanic ejections, and of intervening gorges and occasional table-lands, whose elevations confer on their tropical position the climates of temperate regions.

343. Though observations have been made at numerous detached points, the geological structure of the continent is yet imperfectly known. It has been ascertained, however, that the great plains above alluded to are of tertiary or post-tertiary origin; that primary and secondary formations occur in Brazil, Guiana, and Columbia; that a considerable portion of the Pacific seaboard is of recent upheaval; and that within the range of the

Andes there are vast exhibitions of crystalline and Archæan schists, granites, porphyries, felstones, and other igneous rocks, down to the most recent scorïæ and lavas. The Andes, as well as Brazilian and Columbian sierras, are also rich in metalliferous veins and precious minerals; and, laying aside the recent discovery of the Californian and Australian gold-fields, no other continent has yielded so long and so plentifully such valuable supplies. Gold, for example, is found in New Grenada, Brazil, Chili, Peru, and Bolivia; silver in Peru, Bolivia, Chili, and La Plata; tin and quicksilver in Peru; copper, lead, antimony, iron, &c., in various districts; coal in Brazil, Chili, and Panama; salt in Grenada and La Plata; nitrates of soda and potash in the salinas of La Plata and Peru; diamonds in Brazil; emeralds and other precious stones in most of the higher ranges.

344. With the exception of Tierra del Fuego and Patagonia, which are chilled by the cold currents from the Antarctic Ocean, and the plain of La Plata, which, towards the Atlantic, enjoys a genial and temperate climate, the great bulk of South America, which is the *Neo-tropical* region of biologists, is situated within the tropics, and would consequently be subjected to the uniform temperature of that zone, were it not for the widely different elevations of the surface. These altitudes are not, as might be supposed, tantamount to belts of latitude, but are productive of peculiar climatic results, which are thus graphically described by Malte Brun: The three zones of temperature which originate from the enormous difference of level between the various regions, cannot by any means be compared with the zones which result from a difference of latitude. The agreeable, the salutary vicissitudes of the seasons, are wanting in those regions that are here distinguished by the denominations of frigid, temperate, and torrid. In the frigid zone, it is not the intensity but the continuance of the cold, the absence of all vivid heat, and the constant humidity of a foggy atmosphere, that arrest the growth of the great vegetable production, and in man perpetuate those diseases that arise from checked perspiration. The hot zone of these places does not experience excessive heat, but it is a continuance of the heat, together with exhalations from a marshy soil, and the miasmata of an immense mass of vegetable putrefaction, added to the effects of an extreme humidity, that produces fevers of a more or less destructive nature, and spreads through the whole vegetable and animal world the agitation of an exuberant but deranged vital principle. The temperate zone, by possessing only a moderate and constant warmth like that of a hothouse, excludes from its limits both the animals and vegetables that

delight in the extremes of heat and cold, and produces its own peculiar plants, which can neither grow above its limits, nor descend below them. Its temperature, which does not brace the constitution of its constant inhabitants, acts like spring on the diseases of the hot regions, and like summer in those of the frigid zones. Accordingly, a mere journey from the summit of the Andes to the level of the sea, or *vice versâ*, proves an important medical agent, which is sufficient to produce the most astonishing changes on the human body ; but living constantly in either one or other of these zones must enervate both the body and the mind by its monotonous tranquillity. The summer, the spring, and the winter are seated on three distinct thrones which they never quit, and are constantly surrounded by the attributes of their power.

345. As might be expected from its vast river-plains, tropical situation, and excessive humidity, the continent of South America stands unrivalled in the luxuriance of its vegetable life. In no region is the true tropical forest seen in such perfection, in none is rapidity of growth so remarkable, and in none is there such a development of verdure and foliage. Here are the great headquarters of the palms and melastomas—the former in numerous genera and species, spreading over an area of nearly 600,000 square miles. “The Amazonian selvas and Brazilian forests present, as we have formerly remarked, the most luxuriant and gorgeous growth of palms and tree-ferns, tangled with rope vines and other parasitical climbers, and studded with the strangest forms of the orchids. Here also flourish the mahogany and other timber trees ; the dye-woods of commerce ; the siphonia or india-rubber tree ; the Brazil-nut, vegetable ivory, and castor-bean ; the banana, anana, pine-apple, agave, guava, custard-apple, cassava, pepper-plants, and cactuses of innumerable species, yams, potato, arrow-root, &c. ; while the river-creeks are covered with the most gorgeous floaters, among which is the celebrated *Victoria Regia* of Sir Robert Schomburgk. The higher grounds of Peru and Bolivia are the headquarters of the cinchonas or medicinal barks ; the escallonias and calceolarias ; and there also flourish the milk-tree, the courbaril or copal-tree, and araucaria. In Paraguay is grown the maté or Paraguay-tea tree ; and in the more tropical portions are cultivated the sugar-cane, coffee, cocoa, chocolate, tapioca, arrow-root, indigo, tobacco, cotton, and a thousand luscious fruits ; while in Chili, ‘the Italy of South America,’ are grown the vine, olive, and European fruits.”

346. But while the vegetable element predominates, the animal is subordinated ; and, as formerly stated, the fauna of South

America is greatly inferior, both in importance and variety, to that of the Old World continents, or even to that of North America. Its tropical regions excel, it is true, in the intensity of their reptilian and insect life, but in all the higher orders there is a remarkable paucity compared with its area and vegetation. Its monkeys, though in myriads, are inferior to the orang-outangs, chimpanzees, and gorillas of the Old World; its bats are numerous, but less so than in the Indian Archipelago; its chief carnivora are the puma, jaguar, and ocelot, representing the lion, tiger, panther, leopard, &c., of Asia and Africa; its gnawers (cavies, chinchillas, agoutis, pacas, &c.) are everywhere abundant; its only ruminants are the alpaca, and some small species of deer, there being no natural hollow-horned ruminants, like the ox, sheep, goat, or antelope; the edentata (sloths, armadilloes, anteaters, &c.) are characteristic of the continent; the only important pachyderm is the tapir; and the chief marsupial the opossum. All its domestic animals—horse, ass, ox, sheep, goat, pig, dog, cat, poultry, &c.—are imports from the Old World; the only animal it has furnished in return being the alpaca, whose naturalisation in Europe can scarcely yet be said to be established.

347. Ethnologically, the existing condition of South America is extremely curious and complicated. Originally inhabited by the Indian or Red races, some of whom, like the Toltecs or Aztecs of Peru and Bolivia, had made considerable progress in civilisation, it is now partly peopled by Indians, partly by negroes, partly by Europeans (Spanish, Portuguese, British, French, Dutch, &c.), and largely by a mixed race that has arisen from the intercommunion of these varieties. Although there is a large infusion of the Spanish and Portuguese element, the coloured races are still the most numerous, and all the other—English, French, North Americans, &c.—may be regarded as traders and adventurers, rather than settlers in any of the so-called republics. In this way, though civilisation is extending, it has by no means made satisfactory progress. Little has been done, or is doing, in the arts and manufactures; and the industry of the inhabitants is chiefly directed to raising and collecting raw produce—minerals and metals; hides, skins, tallow; woods, dye-stuffs, medicinal barks, india-rubber, fibres, gums; sugar, coffee, cocoa, fruits, and farinaceous products—for shipment to Europe. The continent, however, has numerous and noble facilities; and now, since the establishment of more frequent communication with Europe and the United States, the introduction of steam navigation in her rivers, and the adoption of more perfect mechanical appliances, we may naturally look forward to the infusion of better elements

of immigration, more permanent settlement, and, as a consequence, better government, and more satisfactory progress.

Oceania.

348. This term has been applied by modern geographers to the numerous islands that are scattered over the bosom of the Pacific and Southern Oceans. Embracing the Indian Archipelago, Australia and adjacent islands, and the truly pelagic groups of the Pacific, its limits may be said to extend from lat. 50° south to 30° north, and from long. 96° east to 150° west in the opposite hemisphere. Its land area has been roughly estimated at 4,200,000 square miles, the greater bulk of which is intertropical, and consequently characterised by the climate and products of the torrid zone. It is usual to arrange the whole into several sections (par. 38), but the following—Malaysia, Australasia, and Polynesia—are sufficient for our review, it being borne in mind that the further the groups are removed from the continents on either side the Pacific, the more peculiar do they become in their climatic and vital aspects.

349. Of the first great section, *Malaysia*, which includes the whole of the Indian Archipelago, and lies between lats. $12^{\circ} 40'$ south, and 20° north, it may be remarked that, being strictly intertropical, and separated from the mainland of Asia only by the narrow Strait of Malacca, the Chinese Sea, and Strait of Formosa, it partakes largely of the characteristics of Further India. Consisting of several large islands (Borneo, Sumatra, Java, Celebes, Luzon, &c.) and of minor clusters and chains intersected by narrow straits and intricate channels, its position and configuration are extremely diversified; while its contour is rendered boldly irregular by numerous lines of volcanoes, extinct and active, many of which rise from 6000 to 10,000 and 12,000 feet in height—the culminating altitude being Singalang in Sumatra, 15,000 feet. Hilly and irregular, there are no plains deserving of the name; insular and humid, there are no arid deserts; and, lying directly under the equator, the lowlands abound in jungle and unhealthy swamp, while the uplands are covered by magnificent forest-growth. As might be expected from the proximity, its vegetable and animal productions, with a few exceptions, are specifically the same as those of the tropical mainland. It forms indeed a portion of the Indian or *Oriental* region of biologists. The following form the principal exports of the Archipelago: In the *mineral* kingdom, gold, tin, antimony, bismuth, copper, iron, coal of oolitic

age, diamonds, emeralds, and other precious stones : in the *vegetable*, nutmegs, cloves, cinnamon, pepper, ginger, and other spices ; coffee, sugar, gums, camphor, cocoa, betel, areca-nuts ; indigo, tobacco, cotton, and other fibres ; maize, rice, sago, tapioca, cassava, bread-fruit ; canes, rattans, bamboo, sandal-wood, teak, and other timber—and, according to competent authorities, a large portion of the country is well fitted for the growth and cultivation of tea ; and in the *animal*, ivory, hides, pearls, tortoise-shell, bird-skins and feathers, edible bird-nests, whale-oil, sharks' fins, ambergris, and similar products.

350. The native inhabitants consist of numerous tribes of the Malay race—Malays, Javanese, Battaks, Dyaks, Bugis, Macassars, Sooloos, &c. ; and the foreign settlers of Chinese and Hindoos from Asia, and Spaniards, Portuguese, Dutch, and British, from Europe. There is also an increasing mixed race ; but neither these nor any section of the natives have made much progress in the arts or manufactures, while the majority of the independent tribes continue in a state of semi-barbarism. Industrially, the growing of maize, rice, cotton, coffee, &c., the gathering and preparing of raw produce for shipment, fishing, and navigation, are the main employments of the most of these rich and fertile islands, whose principal drawback to a better state of things is their sickly and enervating climate.

351. The largest, and in point of promise the most important, section of Oceania, is *Australasia*, which embraces Australia, Tasmania, New Zealand, New Guinea, New Britain, New Ireland, New Caledonia, New Hebrides, Solomon's group, and other minor islands, lying between the equator and 47° south lat., and between long. 112° and 180° east. Of New Guinea and the other islands that lie within the tropics, very little is known ; but such travelers as have visited them describe their soil as very life-giving and nutritious—producing luxuriantly bananas, yams, sweet-potatoes, sugar-cane, bread-fruits, tobacco, water-melons, sago-palm, &c., but inhabited by few mammals (pig, dog, flying squirrels, bandicoot, and kangaroo), though shells, insects, and reptiles are abundant. Australia partly tropical and partly temperate, Tasmania temperate, and New Zealand also temperate, are the better known and most important portions. Australia, whose extreme dimensions are about 2400 miles from east to west, and 1700 from north to south, may be regarded as a minor continent, enjoying a tropical climate in its northern and a warm-temperate in its southern regions. With the exception of the chain running along the eastern coast (par. 76) there are no known mountains or hill-ranges of any elevation in Australia ; the interior of the

continent is in general flat, or but slightly undulating, and only occasionally interrupted by rocky eminences ; while large tracts of the southern and western seaboard are sandy and shingly. The absence of mountain-ranges and high grounds to attract the rain renders the climate of Australia extremely arid ; hence, unless in the New South Wales and Queensland districts, there are no rivers of importance, and none of these navigable ; while in the interior what are running channels during the rains are mere pools and brackish creeks during the long-continued seasons of drought. The climate in the settled districts of New South Wales, Queensland, Victoria, and South Australia is described as delightful, but liable to sudden changes, and occasionally to destructive droughts ; while in the interior it is hot and arid, and though the explorers who recently crossed the continent from south to north occasionally met in with wooded and grassy flats, the journey on the whole was through a shingly, scrubby, and waterless country. Tasmania, which occupies an area of about 24,000 square miles, has more hill and dale than Australia, is better watered, and altogether a milder and finer country. New Zealand, which consists of three contiguous islands, about 1100 miles in length, and varying from 5 to 200 miles in breadth, has from its latitude a still more temperate climate, at least in all the low grounds and along the seaboard (for on the higher elevations it is often cold and stormy) ; is also more hilly and irregular in surface as well as in shore-line ; and has, moreover, a copious supply of water.

352. All of these settlements (Australia, Tasmania, and New Zealand) exhibit a variety of geological formations from the old gold-bearing schists down to the most recent gravels, coral-reefs, and volcanic ejections. They are especially rich in the useful minerals and metals—gold, copper, iron, coal, limestone, marble, jade, and building-stone ; and these supplies must naturally contribute to their future progress, as they have already done to their rapid colonisation. Australia, which forms, with New Guinea and some of the neighbouring islands, the *Australian* region of biologists, is strongly individualised by peculiar animal and vegetable forms of life. Though devoid of the rich and varied vegetation of tropical regions, these areas are well supplied with useful timber-trees, species of araucaria, eucalyptus, and casuarina (the Norfolk-pine, blue-gums, iron-barks, stringy-barks, swamp-oaks, &c., of the settlers) being numerous and characteristic ; while all the cultivated grains, fruits, and vegetables introduced by the European settlers, from the vine, olive, and peach down to the humblest garden produce, can be grown to perfection. With the exception of the dingo or native dog of Australia (the aboriginal

existence of which is even problematical), there were no mammals in Australasia at the time of its discovery beyond kangaroos, opossums, wombats, and other marsupial genera. All the domesticated animals have been introduced by the settlers; to whom, and to the Acclimatisation Society of New South Wales, the region is also indebted for the naturalisation of many of the song-birds, useful insects, and fishes, of the other continents. Of course, in matters of this kind, whether vegetable or animal, the different colonies will be ultimately governed by their geographical position and climate—that which is practicable in New Zealand being impracticable in New South Wales, and what is possible in Southern Australia being impossible in the northern and tropical latitudes of Carpentaria.

353. Ethnologically, the aborigines of the different islands of Australasia are regarded as widely different families of the Malay race—the dark and savage Papuans of New Guinea and adjacent islands, the feebler and wandering tribes of Australia, and the active, daring, and more intelligent Maories of New Zealand, being the principal offshoots. As yet the Papuans have been little interfered with; the Australian tribes are rapidly disappearing before the advances of the white settlers; and though the Maories have shown more aptitude to imitate, and greater boldness to resist, there can be little doubt that they too must shortly succumb to the influences of a higher civilisation. In all the colonies of Australasia belonging to the British, the settlers are principally English, Scotch, and Irish, with a slight infusion, however, of other Europeans, and even Chinese, attracted by the lottery of the gold-fields. As the British element so greatly predominates, with British laws, manners, and appliances, and with, moreover, the most intimate intercommunication with the mother country, the current of Australasian civilisation may be said to run parallel with that of Europe, and can only, after the lapse of generations and the influence of new geographical conditions, be expected to exhibit peculiarities of its own. In the mean time, with their wide pasture-runs, gold-fields, coal-fields, iron-mines, copper-mines, and the facilities of steam communication, the colonies of Australasia are making rapid material progress; and it may be fairly questioned whether, since the establishment of New South Wales in 1788, and of the other provinces since 1828, any settlements under British rule ever exhibited, with less trouble and expense to the mother country, an equal amount of satisfactory and hopeful advancement.

354. *Polynesia*—the usual term employed to designate the numerous islands that stud the bosom of the Pacific within 30

degrees on either side of the equator—embraces the Sandwich, Ladrões, Marquesas, Society, Friendly, Feejee, and other groups, with many other minor clusters and solitary islets that have scarcely a name. Many of these islands, like the Sandwich, Society, and Marquesas, are of volcanic origin, and are still the seats of the most gigantic igneous eruptions; some have old volcanic foundations surmounted and surrounded by upheaved coral-reefs; while others are mere coral-reefs more or less elevated above the level of the ocean. Many of these are extremely irregular in surface, and some, like the Sandwich volcanoes, rise to great altitudes (10,000, 12,000, and 16,000 feet); but, being generally of small dimensions, there is wanting that breadth of surface necessary to the formation of rivers, plains, and other features of geographical diversity. Being of recent geological origin, they afford no mineral or metallic wealth, and their main value lies in their fine climate and the fertility of their soil. Situated within the tropics, but tempered on all sides by the ocean, by the constant aerial currents which are scarcely interrupted by their dimensions, as well as by their frequent elevation of surface, their climate is said to be delightful, though somewhat enervating and monotonous. Their native productions are the cocoa, bread-fruit, banana, plantain, taro, yam, batata, and other tropical fruits and roots; while the orange, lemon, sugar-cane, cotton, potato, melon, guava, and the like, have been successfully introduced, and flourish luxuriantly in all the larger islands. When first noticed by Europeans there were no quadrupeds on any of the islands, save hogs, dogs, and rats (and these may have been the produce of stocks left by previous vessels); but now the horse, ox, goat, sheep, pigs, poultry, and other domestic animals, have been introduced into the larger islands. Most of the islands abound in birds, the shores in sea-fowl, and the waters in fishes, crustacea, turtles, seals, and cetacea.

355. The natives scattered over Polynesia seem offshoots of the Malay race, and though utterly uncivilised, idolatrous, addicted to cannibalism and other barbarous vices, are yet, on the whole (apparently from the unvarying nature of their climate, easy means of subsistence, and isolation), comparatively mild and tractable in their dispositions. This has led to some degree of civilisation in the Sandwich, Society, and Friendly Islands, chiefly through the exertions of British, French, and American missionaries; but as yet to little of that kind of progress which indicates the existence of an inherent and self-sustaining power of improvement. Indeed, it may be questioned how far the limited areas of these islands, the distance of the groups, the want of mineral,

and metals, the enervating effects of climate, and the easy means of subsistence, will permit of more than a dependent condition of civilisation to the inhabitants of Polynesia.

356. Such are the principal land-areas which form the great themes of Physical Geography—the storehouses of the minerals and metals, the stations of the vegetable and the habitats of the animal kingdom, and thus the varied and inexhaustible fields of human industry and civilisation. Consisting of different geological formations, they possess different minerals and metals; and having different positions, configurations, and contours, they enjoy different climates, and consequently produce different vegetable and animal substances. These differences give rise to actions and reactions, physical and vital—for it is only where differences exist that activities are excited—and in this manner are produced the whole round of phenomena that form the sum and substance of cosmical progress. In the physical world, from the revolution of the planets down to the simplest chemical combination, we see and believe that the whole is the result of law and law-directed forces; and in like manner, in the intellectual world, we may rely, though we cannot always determine, that all the phenomena of civilisation are under the direction of laws as pervading and imperative. To observe and arrange the phenomena of the teraqueous surface, to discover their producing causes, and to give intelligible expression to the law that regulates, is the great object of our science, and it only partially performs its function when, in dealing with the human species, it fails to be guided by the same methods of research. Directed by these methods, and applying them to the whole field of nature, the ordinances of our planet, amid all their myriad ramifications, assume a unity and completeness which it is the great object of Science to discover, and the highest effort of Philosophy to establish.

GLOSSARY.

A

- ABERRANT** (Lat. *aberrare*, to wander from).—Departing from the regular or normal type. Applied in Natural History to forms that differ widely from the ordinary or typical ones.
- ABNORMAL** (Lat. *ab*, from, and *norma*, a rule).—Without rule or order; irregular; in a condition differing from that produced in the regular course of nature; deviating from the general type or form; not occurring in the usual order, or according to that which is generally considered as the natural law.
- ABORIGINES** (Lat. *ab*, from; *origo*, beginning or origin).—The first or primitive inhabitants of a country; the original stock (flora or fauna) of any geographical area.—**ABORIGINAL**: first; primitive; original.
- ABSORBENT** (Lat. *ab*, and *sorbeo*, I suck in).—Capable of sucking in fluids; in Geography, applied to those soils and subsoils which have the quality of readily imbibing water into their pores or interstices.
- ABYSSAL** (Lat. *abyssus*, a bottomless gulf).—Occurring at great depths.
- ABYSSAL DEPOSITS**.—Deposits occurring in the ocean depths greater than one mile from the surface. At depths between one and two and a half miles is generally found the *Globigerina Ooze*, formed mainly of the shells of calcareous Foraminifera (*Globigerina*, &c.). At a depth of about two and a half miles, this merges into the so-called *Grey Ooze*, due possibly to the partial removal of the calcareous matter from the ordinary materials of the *Globigerina Ooze*. At greater depths these oozes give place to the *Abyssal Clays*. These are frequently of a red or purplish tint, and have been referred by some to the same source as the *Grey Ooze*, and by others to the slow decomposition of volcanic materials.
- ABYSSAL FAUNA**.—At all depths exceeding one mile from the surface, the fauna of the ocean waters is one of extreme uniformity. All the invertebrate classes of animals are apparently represented within it, but in a proportion different from that which obtains in shallower water. The molluscs so abundant in the littoral fauna are comparatively rare and insignificant in these ocean depths, where the most characteristic forms are rhizopods, sponges, encrinurites, star-fishes, sea-urchins, and remarkable types of crustaceans and fishes.
- ACCLIMATISE** (Fr. *acclimater*).—To accustom a plant or animal to a climate not natural to it; to accustom to the temperature and conditions of a new country. Plants and animals may, within certain limits, become acclimated, and flourish and increase in a new country, though not indigenous to it.
- ACOTYLEDONOUS** (Gr. *a*, without; *kotyledon*, seed-lobe).—Plants whose embryos have no seed-lobe or seminal leaves are so termed, in contradistinction to *Monocotylédons* and *Dicotylédons*, which see.
- ACROGENOUS** (Gr. *akros*, the top; *gignomai*, I am formed).—Applied to those cryptogamic plants which increase by growth at the summit, or "growing point," as the tree-ferns. *Acrogens* are therefore separated as a great botanical division from the *Thallogens*, *Exogens*, and *Endogens*.
- AERIAL** (Gr. *aër*, the air).—Of or belonging to the air or atmosphere; frequenting the air; growing in the air.—**SUB-AERIAL**; taking place under the air, or on the earth's surface, in contradistinction to *sub-aqueous*, or under the water.
- AERIFORM** (Gr. *aër*, air; Lat. *forma*, likeness).—Air-like; applied to gaseous fluids, from their resemblance to common air.
- AEROLITE** (Gr. *aër*, air; *lithos*, stone).—Literally, *air-stone*. The so-called

meteorites or *shooting-stars*, — small planetary bodies or mineral masses, which, in travelling through space, enter the earth's atmosphere, where their own proper motion is partly arrested. The friction generated by their excessive speed causes them to become intensely heated in their passage through the air. They glow with a brilliant light, and, as a general rule, appear to become wholly vaporised. Occasionally, however, they burst with a loud explosion, and their scattered fragments fall to the ground. These fragments afford conclusive evidence that meteorites consist generally of metallic and stony materials, combined in various proportions. They have been grouped under four distinct heads: (1.) *Holosiderites*, consisting almost entirely of metallic iron, or of iron alloyed with nickel, together with sulphides, phosphides, and carbides of several metals. (2.) *Syssiderites*, formed of a net-work of metallic iron, enclosing granular masses of stony material. (3.) *Sporadosiderites*, formed of a matrix of stony material with included particles of metallic iron. (4.) *Asiderites*, composed wholly of stony material. The stony portions of meteorites consist of well-known terrestrial minerals, which occur, however, in combinations different from those met with in the accessible portions of the earth's crust. The meteoric minerals include olivine, enstatite, magnetite, chromite, &c., but quartz, orthoclase, and mica are almost invariably absent. The associated metals are numerous, and embrace, among others, iron, nickel, chromium, tin, magnesium, calcium, titanium, and strontium. Meteorites occur in vast numbers in that part of the heavens traversed by the earth in its annual course round the sun: the average number traversing the atmosphere in the course of twenty-four hours, of sufficient size to make themselves visible to the naked eye, has been calculated at seven and a half millions. Many appear to occur singly, but the vast majority are collected into groups or systems, which circle round the sun in orbits of a greatly elongated form, corresponding to those of the comets, with some which astronomers have determined that certain of the meteoric groups are probably identical.

AFFLUENT (Lat. *ad*, to, and *fluens*, flowing). — Applied to any stream that flows directly into another—the larger or more important being regarded as the *recipient*, and the smaller the *affluent*. — See *Tributary*.

AIGUILLE (Fr.) — A needle; applied in Physical Geography to the sharp serrated peaks of lofty mountains. It is

generally the harder crystalline rocks — gneiss, mica-schist, and the like — which weather into the *aiguille* or needle-top.

ALGÆ (Lat. *alga*, sea-weed). — The general scientific term for those cellular aquatic plants familiarly known as "sea-weeds." Though mostly of marine habitat, many are of fresh-water growth, lacustrine, or fluvial.

ALLUVIUM, **ALLUVIAL** (Lat. *ad*, together, and *luere*, to wash). — Matter washed or brought together by the ordinary operations of water is said to be *alluvial*, and the soil or land so formed is spoken of as *alluvium*. The soil of most of our river-plains (dales, vales, holmes, and carses) is of alluvial formation — some of these low grounds being occasionally overflowed by the muddy waters of the river during seasons of flood, while others have once been the sites of lakes, estuaries, and shallow arms of the sea.

ALPINE. — Belonging to the Alps; but also employed in a general sense to denote extreme heights, or plants, animals, and phenomena appertaining to such heights.

ALPINE or ARCTIC-ALPINE FLORA. — The name given by Bentham to the most remarkable division of the great northern Flora. It consists chiefly of plants of insignificant size, slow growth, but of great longevity and hardness. It is present in part in almost every latitude of the globe where the physical conditions admit of it; occurring at the sea-level in the Arctic regions, and at greater and greater heights as we proceed towards the equator. Its widespread distribution has been explained upon the theory that during the intense cold of the glacial period the former plants of temperate and sub-tropical regions were unable to withstand the rigours of the climate, and were driven to the southward, their place being taken by the hardier Arctic forms of vegetation. As the climate gradually ameliorated, the southern forms again returned to the warm, low-lying regions of their former habitat, but were unable to dispossess the hardier arctic plants of the colder mountain-heights, where the descendants of the latter still flourish.

AMPHIOENS (Gr. *amphi*, all around, and *ginomai*, I am formed). — Plants which increase by the growth or development of their cellular tissues on all sides, as the lichens.

ANADROMOUS (Gr. *ana*, upwards, and *dromos*, a flight or running). — Applied to aquatic animals which, like the salmon and sturgeon, periodically forsake the waters of the ocean and ascend into fresh-water lakes and

rivers for the purpose of spawning. Fishes are thus spoken of as *marine*, *fresh-water*, and *anadromous*, the two former never quitting their native elements, and incapable of subsisting in any other, and the latter possessing the power and habit above alluded to.

ANALOGY (Gr. *ana*, along with, and *logos*, reasoning).—That relationship, resemblance, or correspondence which one object bears to another in functional duty or performance.—**ANALOGUES**, the objects that bear such resemblance or relationship.

ANCHORAGE or **ANCHOR-GROUND**.—Any portion of a bay, estuary, channel, or arm of the sea, where the bottom is unimpeded by rocks, and the water is of a suitable depth for ships riding at anchor.

ANEMOMETER (Gr. *anemos*, the wind; *metron*, a measure).—An instrument (of which there are several kinds) for determining the direction and measuring the velocity and force of the winds. In Robinson's anemometer, the velocity is calculated from the number of revolutions made in a given time by a series of hollow cups supported upon a freely moving framework, and driven by the wind. In Osler's anemometer, the force of the wind is ascertained by noting the pressure which it exerts upon a plane sheet of metal which is kept perpendicular to the direction of the wind by means of a vane.

ANEROID (Gr.).—Literally, without fluid. In the *aneroid barometer* the pressure of the atmosphere is measured by the elevation or depression of the surface of a closed metallic vessel partially exhausted of air. The pressure of the atmosphere being marked at a given time, any alteration is indicated by the movements of the surface of the thin corrugated metal, and communicated to wheels marking the change on a dial furnished with an index. Being easily carried about, the *aneroid* is extremely useful in enabling the traveller and tourist to approximate the relative heights of situations. It is by no means so trustworthy, however, as the ordinary mercurial barometer, being liable to irregularities, owing to changes in the elasticity of the metal of which it is constructed.

ANTARCTIC (Gr. *anti*, opposite, and *arctic*).—Applied to the regions surrounding the south pole, as being opposite to those of the *Arctic* or north pole, which see. Thus, we speak of "antaretic regions," "antarctic circle" (66½° south of the equator), and of situations "within the antarctic circle."

ANTHRACITE (Gr. *anthrax*, coal).—A

variety of coal almost wholly deprived of its natural gases,—hydrogen and oxygen,—and which, therefore, burns without smoke or flame. It may be regarded as a natural coke or charcoal, formed from ordinary bituminous coal by subterranean or chemical heat. It occurs in many coal-fields, but largely, and on a most available scale, in the United States of America.

ANTIPODES (Gr. *anti*, opposite; *pous*, *podos*, foot).—Applied to those who dwell on opposite sides of the globe, as having their feet diametrically opposed. Those in New Zealand, for example (or rather Antipodes Island, near New Zealand), are the antipodes of those in Great Britain.

ANTISEPTIC (Gr. *anti*, opposed to; *septos*, decayed).—Substances which, like common salt and tannin, prevent putrefaction in animal and vegetable matter, are said to be *antiseptics*, or to possess *antiseptic properties*.

APHELION (Gr. *apo*, from; *helios*, the sun).—The point in a planet's orbit at which it is farthest from the sun; its *perihelion* being the point at which it is nearest.

APOGEE (Gr. *apo*, from; *ge*, the earth).—That point of the moon's orbit in which she is farthest from the earth; her *perigee* being the point in which she is nearest the earth.

AQUATIC (Lat. *aqua*, water).—Relating to the water; having its habitat or usual position in water. Applied to plants which, like the water-lily, grow in water, and to animals which, like the duck and diver, live in or frequent the waters.

AQUEOUS (Lat. *aqua*, water).—Watery; pertaining to, or formed by, water. We thus speak of aqueous vapours, aqueous solutions, aqueous or sedimentary strata, and the like.—**SUB-AQUEOUS**: occurring under the water; in contradistinction to *sub-aerial*, or under the open air.

ARCHIPELAGO (Gr. *archos*, chief; and *pelagos*, sea).—The name given by the Greeks to the *Ægean Sea*. This sea is studded with islands, and the name *archipelago*, having been applied to similar island-studded seas elsewhere, is now, by a very natural transition, used to designate any cluster or group of islands—e.g., the Indian Archipelago, or East India Islands.

ARCTIC (Gr. *arktos*, a bear).—Relating to the north pole or polar regions; in reference to the constellations of the Great and Little Bears which occur in the northern quarter of the heavens, and point, as it were, to the north pole.—*Arctic Regions*, the high latitudes surrounding the north pole: *Arctic Circle*, an imaginary line extending

round the north pole $66\frac{1}{2}^{\circ}$ from the equator and parallel to it; hence certain parts are said to "lie within the arctic circle."

ARGENTIFEROUS (Lat. *argentum*, silver; *fero*, I yield).—Applied to veins, rocks, and other matrices containing the ores of silver, or silver in the native or metallic state.

ARGILLACEOUS (Lat. *argilla*, clay).—Applied to all soils, rocks, or substances composed of clay, or having a notable proportion of clay in their composition.

ARM.—Any deep and comparatively narrow branch of the sea running inland, in contradistinction to gulfs and firths.

ARTESIAN WELLS.—Wells sunk by boring perpendicularly through the solid strata, and in which the subterranean waters rise to the surface, or nearly so. This method of obtaining water has long been known and practised in the province of Artois (the ancient Artois, and hence the name), in France. Artesian wells are generally situated in plains, or in basin-shaped valleys towards which the strata dip on both sides, and their principle depends upon the hydrostatic pressure of the water percolating the inclined strata. This forces its way upward by the artificial orifice to the highest level of the water-bearing stratum. The greater the depth the higher the temperature of the water; and the lower the surface of the well compared with the outcrop of the water-yielding stratum, the higher will the jet of water rise above the orifice of the bore.

ASTEROIDS (Gr. *aster*, star; *eidos*, likeness).—A term applied by Herschel to the minor planets or *planetoids*—Ceres, Pallas, Juno, Vesta, &c.—of which there are now upwards of two hundred and ten known to astronomers.

ATMOMETER (Gr. *atmos*, vapour, and *metron*, measure).—An instrument measuring the amount of evaporation in any locality. It consists of a long glass tube, having at the bottom a hollow ball of porous earthenware. Water is poured into the tube, and the outside of the porous ball being always covered with dew, the rate at which the water falls in the tube indicates the rapidity of evaporation in the air around.

ATMOSPHERE (Gr. *atmos*, vapour; *sphaira*, sphere).—The gaseous envelope or volume of air which surrounds the earth on every side, and which is either directly or indirectly the cause of numerous geological and geographical operations, as well as the immediate medium of all climatic diversity—being the great laboratory in which all meteorological and electrical phenomena are elaborated, as winds, clouds, rains, snow, hail, and thunder-storms. It is

composed of 79 parts nitrogen and 21 oxygen, with variable traces of carbonic acid and other impurities. Calculating from its decreasing density, as well as from its diminished power of refracting light, as we ascend from the earth, the height of the appreciable atmosphere has been estimated at 45 or 50 miles; and the pressure of the whole volume on every square inch of the earth's surface (at the ordinary sea-level) at 14.6 lb. avoirdupois.

ATOLL.—The name given to a coral island of an annular form—that is, consisting of a circular belt or strip of coral-reef more or less continuous, with an enclosed lagoon.

AURIFEROUS (Lat. *aurum*, gold; *fero*, I yield).—Yielding or containing gold; applied to veins, rocks, and rock-substances containing the precious metal, as "auriferous veins," "auriferous gravels," and the like.

AURORA BOREALIS (Lat.).—Literally the "Aurora of the North;" known also as the *Northern Lights*, *Polar Lights*, *Streamers*, &c. A luminous appearance, generally occurring in the northern heavens, and so called from its resemblance to the *aurora* or morning twilight. It is usually referred to electrical agency in the upper regions of the atmosphere. It is unquestionably connected in some way with terrestrial magnetism. The magnetic needle is greatly agitated when the aurora is visible. When the arch is motionless the needle is motionless, but when streamers are emitted, the needle commences its vibrations, which correspond precisely to those of the aurora, both in intensity and duration. Changing from the purest and softest white to all the colours of the rainbow, and flickering and flitting from the horizon to the zenith with inconceivable rapidity, the aurora borealis is one of the most attractive of celestial phenomena. Auroras are most frequent between the parallels of 50° and 62° N., where the average is about 80 annually. They are often of extraordinary extent, having been sometimes simultaneously observed on both sides of the Atlantic. In height they vary from 45 to 500 miles above the surface of the earth.

AUTUMN (Lat.).—The third quarter of the year, which commences when the sun enters *Libra*—that is, about the 21st or 22d of September, when the days and nights are equal; hence the term *Autumnal Equinox*, or *Autumnal Point*, referring to the corresponding point of the ecliptic.

AVALANCHE (Fr. *avalanche*, *lavange*, *lavanche*).—An accumulation of snow, or of snow and ice, which descends from precipitous mountains like the Alps into the valleys below. Avalanches origi-

nate in the higher regions of mountains, and begin to descend when the gravity of their mass becomes too great for the slope on which it rests, or when fresh weather destroys its adhesion to the surface. They are usually distinguished as *Drift*, *Rolling*, *Sliding*, and *Glacial Avalanches*: *Drift* are those caused by the action of the wind on the snow while loose and powdery; *Rolling*, when a detached piece of snow rolls down the steep, licks up the snow over which it passes, and thus acquires bulk and impetus as it descends; *Sliding*, when the mass loses its adhe-

sion to the surface, and descends, carrying everything before it unable to resist its pressure; and *Glacial*, when masses of frozen snow and ice are loosened by the heat of summer and precipitated into the plains below.

AXIS (Lat. a pole or axletree).—A word used largely and variously in natural science; applied to the line about which objects are symmetrical, about which they are bent, around which they turn, or to which they have some common relation; hence "vertebral axis," "axis of elevation," "axis of rotation," "synclinal axis," &c.

B

BAROMETER (Gr. *baros*, weight; *metron*, measure).—An instrument for measuring the height of a column of mercury when supported by the pressure of the atmosphere; and by this test determining the weight of the air. The variations in the pressure of the atmosphere are indicated by corresponding variations in the height of the barometric column, which thus affords a means of foretelling such changes in the weather as are dependent upon varying air pressure, and of measuring heights and depths, by noting the proportional weight of the column of superincumbent air.—**BAROMETRIC**, belonging to or indicated by the barometer.

BARRIER-REEF.—The name given to those coral-reefs that run parallel (*barrier-like*) to the shores of islands and continents, but are separated therefrom by a lagoon-channel more or less extensive. The barrier-reefs of Australia and of New Caledonia, owing to their enormous dimensions, have long excited the attention of voyagers.

BASIN.—Applied, in Geography, to the whole extent of valley-shaped or basin-shaped country drained by any river and its tributaries, as the "basin of the Thames," the "basin of the Forth," &c.

BATHYMETRICAL (Gr. *bathys*, deep, and *metron*, measure).—Applied to the distribution of plants and animals along the sea-bottom, according to the depth of the zone (measuring from the sea-level) which they inhabit.

BAY.—Any bending of the ocean into the land, less sudden and contracted than a *creek* or *harbour*, and communicating more openly with the main ocean than a *sea* or *gulf*; "Bay of Biscay," "Bay of Bengal."

BEACH.—The shore of the sea; the strand; strictly speaking, that space along the margin of the tidal sea over which the tide alternately flows and

ebbs.—**RAISED BEACHES**, terraciform shelves and flats, generally consisting of shingle and gravel, occasionally containing shells and other marine exuviae, occurring at various elevations above the present sea-level, and thus affording evidence of uprise of the land.

BIOLOGY (Gr. *bios*, life, and *logos*, doctrine).—The science of life, whether vegetable or animal, embracing botany and zoology in their widest acceptation.—**BIOLOGICAL**, relating to the science of life; life in all its multifarious manifestations and developments.

BLUFFS.—A term said to be of American origin, and used to designate high banks presenting a precipitous front to the sea or a river.

Bog (Celtic, *soft*).—The common designation for any wet, spongy, or peaty morass, consisting chiefly of decayed vegetable matter.—**Bog-EARTH**, soils composed in the main of decomposed vegetable matter, with a considerable proportion of light silicious sand.

BOILING-POINT.—The precise temperature at which a liquid begins to *boil* or bubble up under the influence of heat. The boiling-points of liquids are constant under precisely the same circumstances. The causes which induce variation are increased or diminished atmospheric pressure, the greater or less depth of the liquid, and the nature of the vessel in which it is contained. Thus, the boiling-point of water under ordinary circumstances, at the level of the sea, is 212° Fahr.; but it will boil and bubble up at a much lower temperature on the top of a high mountain, in consequence of diminished pressure; it will also boil sooner and more quietly in a rough-surfaced vessel than in a smooth and polished one; and also more quickly in a shallow vessel, in consequence of the less resistance by the superincumbent water to the escape of steam. The boiling-point is also raised considerably by saline admixture, so that pure water,

which boils at 212°, requires 285° when fully saturated with salt.

BORE.—A violent rush of tidal water; the advancing edge or front of the tidal wave as it ascends a river or estuary; *e.g.*, the bore of the Hooghly, the Garonne, the Severn, the Tsientang, &c. The bore of the Tsientang is said to advance up that river at Hangchau like a wall of water, thirty feet in height, and at the rate of twenty-five miles an hour, sweeping everything before it.

BOREAL (Lat. *Boreas*, the north wind).—Of or belonging to the north; *e.g.*, boreal regions, boreal fauna, &c.

BOTTLE-TRACK.—The name given to the course pursued by bottles which are thrown overboard with a note enclosed of the longitude and latitude where, and the date when, they are dropped

in the ocean. By this means the direction and velocity of currents are rudely determined.

BOULDERS (Sax.)—Any rounded or water-worn blocks of stone, which would not, from their size, be regarded as pebbles or gravel, are termed *boulders*. The name, however, is usually restricted to the large and frequently water-worn and smoothed blocks, generally foreign to the locality where they occur ("erratic blocks"), which are found imbedded in the clays and gravel of the Drift formation, which covers the northern hemisphere, in both worlds, down to the 40th or 42d parallel of latitude.

BREEZE.—The general term for a wind of some briskness, but of limited extent and duration; less violent than a *gale*. Its speed varies from fifteen to forty-two miles an hour.

C

CAINOZOIC or CARNOZOIC (Gr. *kainos*, recent; *zoe*, life).—Applied to the upper stratified systems, as containing recent forms of life, in contradistinction to the *Mesozoic* (holding intermediate) and the *Paleozoic* (holding ancient and extinct forms). As a palæontological subdivision, the Cainozoic embraces the tertiary and post-tertiary formations.

CALCAREOUS (Lat. *calx*, *calcis*, lime).—Composed of, or containing a considerable proportion of lime; *e.g.*, *calcareous soils*, *calcareous sandstones*, &c.

CALCARIFEROUS.—Literally, lime-yielding. A term occasionally applied to springs charged with carbonate of lime, and which, on issuing into the air, deposit incrustations of calcareous tufa. The "petrifying springs" of ordinary language.

CALDERA.—A Spanish term for the deep caldron-like cavities that occur on the summits of extinct volcanic mountains and islands, and which are evidently the former craters of ancient volcanoes.

CAPILLARY (Lat. *capillus*, a hair).—Hair-like; applied to filaments, tubes, and the like, of very fine or hair-like dimensions. When a capillary tube is partly immersed in a liquid which wets it, the liquid rises within the tube to a level slightly above that of the general surface of the liquid outside. As this was formerly supposed to be due to some mysterious "attraction" of the tube for the liquid, the phenomenon is still popularly known as "capillary attraction."

CARBONIFEROUS (Lat. *carbo*, coal; *fero*, I yield).—Coal-bearing, coal-yielding. The term is usually applied to that system of strata from which our main sup-

plies of coal are obtained, or to the respective groups or members of that system; *e.g.*, "carboniferous system," "carboniferous limestone," &c.

CARDINAL (Lat. *cardo*, a hinge).—A term implying importance, and suggestive of the hinge or point on which a thing turns or depends. Thus the *cardinal points* of the compass are the North, South, East, and West; the *cardinal signs* of the zodiac, Aries, Cancer, Libra, and Capricorn.

CARNIVORA (Lat. *caro*, *carnis*, flesh, *voro*, I devour).—One of Cuvier's orders of the mammalia, embracing the lion, tiger, hyena, and others that subsist solely on flesh.—**CARNIVOROUS**, living on flesh, in contradistinction to *herbivorous*, *graminivorous*, &c.

CATAclysm (Gr.)—A sudden flood, deluge, or inundation. Generally applied to some abnormal or unusual effect of moving water.—**CATAclysmal**, belonging to, or produced by, the violent force of water.

CHALYBEATE (Gr. *chalybs*, iron or steel).—Applied to springs and waters impregnated with iron, or holding iron in solution.

CIRQUES.—A term applied to the circular or bowl-shaped valleys of the Pyrenees, some of which are of considerable depth and peculiar configurations.

CLIMATE (Gr. *klima*, an inclination).—Originally applied (as explained in the text), in a technical or astronomical sense, to the various belts of the earth as influenced by the heat of the sun; but now applied to the general *weather-conditions* of any district, as these may be mild or rigorous, genial or ungenial, salubrious or obnoxious. In treating of countries, geographers speak of *insular*

and *continental* climates; the former, from its proximity to the ocean, being comparatively mild in winter and cool in summer, and the latter cold in winter but excessively hot in summer.

CORAL-REEF.—The term applied to any connected mass of coral structures, whether trending away in long partially submerged ledges, encircling islands like breakwater-barriers, or rising as low ring-shaped islets above the waters of the ocean. Such masses are found studding the Pacific on both sides of the equator to the thirteenth degree of latitude; abounding in the southern part of the Indian Ocean; trending for hundreds of miles along the north-east coast of Australia; and occurring less or more plentifully, in patches, in the Persian, Arabian, and Red Seas. In the Pacific, coral-reefs are found forming low circular islands enclosing lagoons (*atolls* or *lagoon islands*); surrounding islands of igneous and other origin (*fringing* or *shore reefs*); crowning others already upheaved (*coral-ledges*); or stretching along shore in surf-beaten ridges (*the true barrier* or *encircling reef*) of many leagues in length, and from 20 to more than 200 feet in width. These reefs are wholly composed of a kind of limestone, secreted by the coral-polypes. The larger corals flourish best on the outer parts of the reef, where they are exposed to the action of the waves. The smaller and more delicate kinds inhabit the inner lagoon between the reef and the land. As these animals can only exist within a few fathoms of the surface, while some of these reefs rise up from vast depths in the ocean, and occur at great distances from the nearest land, it has been suggested by Darwin that they owe their present height and position to the upward growth of the corals during a prolonged subsidence of the ocean floor. The corals commenced to build along the shore line of an island, forming first a *fringing reef*, with a shallow lagoon between it and the shore. As the seabed subsided, the upward growth of the coral kept the surface of the reef always at the water-level. In this way the fringing reef became gradually transformed into the more distant *barrier-reef*; and, finally, as the island it originally surrounded sank altogether out of sight, the reef became a ring-shaped *atoll*, with a central lagoon.

Cosmos (Gr. *kosmos*).—Literally, order; natural order, like that prevailing in the universe. The whole framework of the material universe; the *world*, from

the orderly arrangement and symmetry of its component parts.—**COSMICAL**, relating to the world or universe.—**COSMOLOGY**, the science which treats of the several parts of the world, their laws and relations.

COULÉES (Fr. *culer*, to flow, as melted metal).—Applied to the *streams* and spurs of lava which diversify the sides and slopes of volcanic mountains.

CRAIG AND TAIL.—Applied to a form of hills common in Britain, where a bold precipitous front (the *crag*) is exposed to the west or north-west, and sloping declivity (the *tail*) towards the east. In general geographical terms, the *slope* and *counter-slope* of these hills.

CRATER (Gr. *krater*, a cup or bowl).—The mouth or orifice of a volcano: so called from its cup or bowl shape. Craters may be central or lateral in the mountain in which they occur; there may be one principal and several subsidiary ones; and they may become absorbed by subsidence, or be obliterated by eruptions from more recent orifices.

CRATERIFORM.—Applied to hills whose summits present bowl-shaped and other circular depressions that seem to have been the craters of once active volcanoes. We thus speak of the "crateriform hills of Auvergne"—hills which were undoubtedly in a state of igneous activity during the tertiary period.

CREPUSCULAR (Lat. *crepusculum*, dusk).—Applied to animals which are active in the dusk or twilight.

CUPRIFEROUS (Lat. *cuprum*, copper, and *fero*, I yield).—Applied to veins, rocks, and other matrices containing the ores of copper, or copper in the native or metallic state.

CYCLE (Gr. *kuklos*, a circle).—A definite period of time, marked by the recurrence of the same natural phenomena.

CYCLONE (Gr. *kuklos*, a circle).—A term originally applied by navigators to those rotatory hurricanes which occur most frequently between the equator and the tropics, and near the equatorial limit of the trade-winds. The term is now generally applied to the movement of the wind in all storms. Cyclones sweep round and round with a progressive motion, their course describing a curve, and their violence being greater the narrower the limit of their whirl. In both hemispheres the rotation of a cyclone is *contrary* to that of the sun—those in the northern hemisphere moving counter, so to speak, to the motion of a watch-hand, those in the southern following that motion.

D

- DEBACLE** (Fr. *débâcler*, to unbar).—A term originally signifying the breaking up of the ice on a river—a freshet; but now applied to any sudden flood or rush of water which breaks down opposing barriers, and hurls forward and disperses blocks of stone, gravel, and other debris.
- DEBRIS** (Fr. wreck or waste).—A convenient term, adopted from the French, for any accumulation of loose material arising from the waste of rocks; also for drifted accumulations of vegetable or animal matter.
- DEGRADATION** (Lat. *de*, down, and *gradus*, step).—Removing or wasting down step by step. The degradation of hills and cliffs is caused by atmospheric and aqueous agency; hence water is said to exert a *degrading* influence on the earth's crust; waves and tidal currents a *degrading* action on certain sea-shores.
- DELTA**.—The alluvial land formed at the mouth of a river, such as that of the Nile, which received this name from the resemblance of the space enclosed by the two main branches of the river to the Greek letter Δ , *Delta*.
- DEPOSIT** (Lat. *de*, down; *positus*, placed).—Applied to matter that has settled down from suspension in water. Deposits are either distinguished by their composition, as mud-deposits, sand-deposits, &c.; by the positions in which they occur; or by the agencies concerned in their formation, as fluvial, lacustrine, estuarine, marine, &c.
- DETRITUS** (Lat. *de*, down; *tritrus*, rubbed or worn).—A term for all accumulations arising from the waste or disintegration of exposed rock-surfaces, sea-cliffs, mountain-cliffs, river-banks, and the like. *Detrital* matter may thus consist of mud, sand, gravel, rubbly fragments, or of any admixture of these.
- DICOTYLEDONOUS** (Gr. *dis*, double; *kotyledon*, seed-lobe).—A grand division of the vegetable kingdom, comprising all those plants whose seeds are composed of two lobes or seed leaves. They are exogenous, or increase by external layers of growth, and the venation of their leaves is reticulated or net-like, and not in parallel order, as in monocotyledonous endogens.
- DIP**.—The inclination or angle at which strata slope or dip downwards into the earth. This angle is measured, of course, from the plane of the horizon. Some rocks dip at a low angle and are flat; others incline at a very high angle, and are almost on edge.
- DOAB**.—The name given in India to the tongue of land that lies between two or more confluent rivers, as the *doabs* of the Punjab, or plains that lie between the rivers of that region.
- DOLDRUMS**.—A sailor's term for the tropical zones of calms and variables—belts in which they are often detained for weeks by baffling calms, storms, and rains.
- DOWNS** (Brit. *dune*, a hillock).—Applied in the south of England to the rounded, dry, and unwooded chalk hills of Kent, Surrey, Sussex, and adjacent counties. These "downs" are described "as covered with a sweet short herbage, forming excellent sheep pasture, generally bare of trees, and singularly dry even in the valleys that wind for miles between them."
- DRIFT**.—Literally "that which is driven;" as *sand-drift*, sand driven and accumulated by the wind; *drift-wood*, wood carried down by rivers, and driven by tides and currents to distant shores. Such drift-wood is often useful in indicating to geographers the course and direction of oceanic currents. The name Drift period, or period of the Glacial Drift, is occasionally applied to the epoch of the ice sheet in Britain, and the term Glacial Drift itself to the material distributed over the country within that period.
- DRIFT-CURRENTS**.—The name given to oceanic currents which mainly depend on the winds. The monsoons which prevail in the Indian Ocean give rise to drift-currents, which set alternately in one direction and then in another, according to the season of these winds.
- DROSOMETER** (Gr. *dros*, dew, *metron*, measure).—Literally "dew-measurer;" any apparatus or instrument for determining the amount of dew deposited during a single night. "The most simple process," says Professor Kaemtz, "consists in exposing to the open air bodies whose exact weight is known, and then weighing them afresh after they are covered with dew. According to Dr Wells, locks of wool, weighing five decigrammes, are to be preferred, which are to be divided into spherical masses, of the diameter of about five centimetres."
- DUNE** (Brit. a hill).—Usually applied to hillocks of blown sand. *Sand-dunes*, sand-drift like that which, in so many places, skirts the low shores of our own island.

E

EARTH'S CRUST.—That external portion of our planet which is accessible to human investigation; in contradistinction to the internal mass, of which we can know nothing by direct observation.

EARTHQUAKE.—The familiar as well as technical term for the sudden shaking or tremor of the earth's crust produced by subterranean agency. With the causes that produce earthquakes we are but slenderly acquainted; but we know that their results are fractures, fissures, and chasms in the earth's crust; upheavals and depressions; elevations of the sea-bed into dry land, and the submergence of dry land beneath the waters of the ocean.

EDDY (Sax. *ed*, backwards).—Any rotary motion of water caused by the meeting of opposing currents. Eddies generally occur in estuaries where the tide meets the current of the river; and in seas where currents from different quarters meet, or where tidal currents are thrown back on themselves by opposing obacles.

EMBOUCHURE (Fr.).—The mouth of a river, or that part where it enters the sea.

ENDOGENS (Gr. *endon*, within; *ginomai*, I am formed).—A grand division of the vegetable kingdom, including those plants whose growth takes place from within, and not by external concentric layers as in the *Exogens*.

Eozoic (Gr. *eos*, dawn).—The name applied by geologists to the oldest formations (Laurentian, &c.) which are supposed to yield the first evidence of life upon the globe.

EQUATOR (Lat. *æquus*, equal).—The great circle on the earth's surface, every point of which is equally distant from the poles; such a circle cuts the globe into two equal parts or halves—in other words, into *hemispheres*—viz., the Northern and Southern. When the sun is in the line of the equator, day and night are of equal duration, hence it is also termed the *equinoctial line* (*nox*, the night).—**EQUATORIAL**, belonging to, or in the region of, the equator.

EROSION (Lat. *erosus*, gnawed or worn away).—The act of gradually wearing away; the state of being gradually worn away.—Valleys of erosion:—those val-

leys which have been gradually cut out of the solid strata by the long-continued action of the river or rivers that flow through them.

ENRATIC BLOCKS.—A term frequently applied to those large and ice-borne blocks of stone (*boulders*) which are scattered so generally over the higher and middle latitudes of the northern hemisphere.

ESCARPMENT (Fr. *escarper*, to cut steep).—The abrupt face or cliff of a ridge or hill-range.

ESTUARY (Lat. *æstus*—*æstuo*, I boil—the tide; so called from the troubled boiling-up of the water-line, which marks its approach in river-mouths).—Estuaries are, properly speaking, tidal river-mouths, like those of the Thames, Severn, Solway, &c., whose fauna and flora are mixed fresh-water and marine, or composed of such species as are peculiar to brackish waters.—**ESTUARINE**, of or belonging to an estuary, as estuarine deposits, formations, &c.

ETESIAN WIND (Gr. *etesios*, annual).—A northerly, or rather north-easterly wind that prevails very much in early summer all over Europe.

ETHNOGRAPHY (Gr. *ethnos*, a race; *grapho*, a description).—An account or description of the origin, dispersion, connection, and characteristics of the various races of mankind.

EVAPORATION (Lat. *evaporo*, I send off in vapour).—The act of converting into vapour such liquids as water, either by natural or by artificial means. Heat is the grand evaporating agent in nature, and its effects are greatly facilitated by the removal of the vapour as soon as it is formed either by currents of wind, by absorption, or by other analogous means.

EXOGENS (Gr. *exo*, without; *ginomai*, I am formed).—That great division of the vegetable kingdom which embraces those plants whose growth takes place by external concentric layers, and not from within as in the *Endogens*.

EXOTIC (Gr. *exo*, from without).—Applied to plants and animals, but chiefly to the former, that have been introduced into a country from other regions—that is, from without. Used in contradistinction to *indigenous*.

F

FACIES (Lat.).—A convenient term employed to express any common resemblance or aspect among the rocks, plants, animals, or fossils of any area

or epoch. Thus we speak of the "facies of the Carboniferous flora," as distinct from the floras of other epochs; and of the "facies of the Australian fauna," as

distinguished from the animals of other regions by their common marsupial characteristic.

FAMILY.—In Natural History classifications this term denotes the group next in value and comprehensiveness above the *genus*. As species constitute a genus, so genera constitute a family.

FATA MORGANA.—The phenomenon of the *mirage* at sea. It arises from two layers of air of different density coming suddenly in contact. When the upper current is the rarer, the rays of light proceeding from objects in the lower current are gradually refracted within the former, more and more from their naturally straight course, until, finally, the objects appear inversely reflected. As the density of the two currents vary unequally near their plane of contact, various refractions and distortions result, which often impart to the whole a singular and fantastic appearance. On land, where the warmer stratum of air is on the surface of the ground, the aerial mirror is formed beneath the eye of the observer, by which the same appearance is produced that results from the reflection of objects on the surface of the water. The name is said to be of Breton origin—*mor*, sea, and *gana*, fine lady—the fairy mermaid of our popular legends.—See *Mirage*.

FAUNA (Lat. rural deities).—A convenient term for the animals of any given epoch or area; e.g., the "fauna of South America," the "fauna of the Permian era." As the animals of an area or epoch constitute its **FAUNA**, so the plants constitute its **FLORA**.

FERRIFEROUS (Lat. *ferrum*, iron; *fero*, I yield).—Applied to veins, rocks, and other matrices that yield or contain iron.

FERRUGINOUS (Lat. *ferrum*, iron; Gr. *ginomai*, I become).—Impregnated or coated with oxide of iron; rusty-looking.

FJORD (Norse).—A term applied to deep narrow arms of the sea, which run abruptly into the land, and generally with bold rocky shores, as the fjords of Norway and the sea-lochs of Scotland.

FLORA (Lat. the goddess of flowers).—A convenient term for the vegetation of any given epoch or area—as "the flora of the coal-measures"—"the flora of South America." As the plants of a country or epoch constitute its **FLORA**, so the animals constitute its **FAUNA**.

FLUVIATILE (Lat. *fluvius*, a running water).—Belonging to a river; produced by river-action; growing or living in fresh-water rivers.

FLUVIO-MARINE.—Estuarine; partly of

river and partly of marine formation or origin; partly fresh-water and partly salt-water.

Fossil (Lat. *fossilis*, dug up).—Literally, anything dug out of the earth; but now restricted by geologists to "organic remains," or the remains of plants and animals imbedded in the earth's crust, and more or less altered in structure and composition by mechanical and chemical agencies. When these remains are only partially petrified, and occur in superficial or recent deposits, the term *sub-fossil* is employed.

Fossiliferous (Lat. *fossilis*, and *fero*, I bear).—Applied to rocks and rock-systems containing organic remains, in contradistinction to *non-fossiliferous*, or those which contain no such relics.

FRESHET.—A river flood or inundation occasioned by the sudden melting of the ice and snow in spring.

FRINGING-REEFS.—A class of coral-reefs, known also as "shore-reefs," from their fringing or encircling islands at a moderate distance from shore. "They differ from barrier-reefs," says Darwin, "in not lying so far from shore, and in not having within a broad channel of deep water." The reefs which fringe the island of Mauritius form a good example of the class.—See *Coral Reef*.

FRITH (Lat. *fretum*).—An arm of the sea, as the Frith of Forth, the Frith of Tay, &c. Originally applied to any strait, narrow passage, or inlet.

FROST (Sax.).—In Meteorology, the freezing, or conversion into ice, of water and watery vapours by the influence of cold. In ordinary circumstances water passes into ice when the temperature of the air falls to 32° of Fahrenheit. As the cold increases and the frost becomes more intense, other substances (such as oils, mercury, &c.) which remained liquid at 32° gradually part with their heat, and pass into the solid state. As a geological agent, frost exerts a purely mechanical influence, but this influence is of prime importance in disintegrating rocks and soils, moulding the outline of mountains, and assisting in the dispersion of boulders and other debris, not only from higher to lower levels, but from the land over the bottom of the ocean. The *avalanche*, *glacier*, and *iceberg*, among the most notable of geographical phenomena, are the children of the frost, cradled on the snowy summits of lofty mountains, or in the icy seas of the polar regions.

FUMEROLE (Ital. *fumare*, to smoke).—An opening or orifice in a volcanic district from which eruptions of smoke and other gaseous fumes are emitted.

G

GARUA.—The local term for dense sea-fogs that occur periodically along the Pacific coast of South America. During the garua, it is said the atmosphere loses its transparency, and the sun is obscured for months together. The vapours of the garua of Lima are so thick that the sun, seen through them with the naked eye, assumes the appearance of the moon's disc. They commence in the morning, and extend over the plains in the form of refreshing fogs, which disappear soon after midday, and are followed by heavy dews, which are precipitated during the night.

GENUS (Lat. kind or kindred).—In Natural History the word *genus* is generally used to embrace such members of a family or larger group as possess some common properties, more marked in them than in the other members of the family. Thus the *CANIDÆ* or Dog family embraces the dog, wolf, jackal, fox, &c.; but the dog, wolf, and jackal are regarded as one genus, *canis*, while the foxes are separated into another genus, *vulpes*, the points of agreement between the dog and wolf being more numerous and intimate than between the dog and fox.

GEOLOGY (Gr. *ge*, the earth, and *logos*, doctrine), embraces all that can be known of the constitution and history of our planet. Its object is to examine the various rock-materials of which our planet is composed, to describe their appearance and relative positions, to investigate their nature and mode of formation, and generally to discover the laws which seem to regulate their

arrangement. In this respect it differs from *Geography*, which restricts itself more especially to the external or superficial aspects of the globe, and the life that adorns it.

GEYSER.—Literally "rager;" an Icelandic term for the intermittent boiling springs or spouting fountains which occur in connection with the volcanic phenomena of that island. The term has reference to the violent discharges of steam and water which take place at stated intervals, the jets being thrown with explosive force to a great height in the air.

GHAUTS.—A term applied originally to the narrow and difficult passes in the mountains of Southern India, but which has been gradually extended to the mountains themselves—viz., the Eastern and Western Ghauts, which consist of two great chains, stretching along the east and west coasts of the Deccan.

GLACIAL.—Belonging to or produced by ice.—*Glaciation*, the effects of ice-action, such as smoothing and striating of rock-surfaces, and the like.—**GLACIATED**, applied to rock-surfaces that have been smoothed and striated by ice.

GLACIER (Lat. *glacies*, ice).—Applied to those accumulations of ice, or of snow and ice, which collect in the valleys and ravines of snowy mountains like the Alps, and which move downward, mainly under the influence of gravity, with a peculiar creeping motion, smoothing the rocks over which they pass, and leaving mounds of debris (*moraines*), lateral and terminal, as they melt away.

H

HABITAT.—The region occupied by any particular animal is called its *habitat*, and that of any particular plant its *station*—each being the locality which presents the conditions most favourable to its growth and development.

HAIL.—Frozen rain; rain-drops that have been suddenly frozen in their downward course by passing through a stratum of air below the temperature of 32°. Hail pellets are of various forms—round, angular, or flat—and often of considerable size.

HEADLAND.—Any prominent projection of the land into the sea; usually applied to a *cape*, *ness*, or *promontory* of some boldness and elevation.

HERBACEOUS.—Applied in Botany to stems that die down annually, in contradistinction to *ligneous* or woody, persistent stems.

HERBIVOROUS (Lat. *herba*, herb, and *voro*, I devour).—Herb-eating; subsisting on vegetable food; in contradistinction to *carnivorous*.

HOMIOZOIC (Gr. *homoios*, the same, and *zoe*, life).—Zones or belts of the ocean which, being under nearly the same circumstances as to climate, and consequently peopled in their different parts either by the same or representative species of animals, are said to be *homiozoic*, or marked by the same life.

HYGROMETER (Gr. *hygros*, moist; *metron*, measure).—An instrument for determining the humidity of the atmosphere. There are various kinds of hygrometers—some depending upon the principle of the varying contraction of absorptive materials, and others

upon the principle of condensation upon cold polished surfaces.

Hypsometrical (Gr. *hypsos*, height; *metron*, measure).—Altitudinal; applied to zones or belts of elevation on land; as *bathymetrical* is applied to zones of depth in water.

I

ICEBERG (Ger. *eis*, ice, and *berg*, mountain).—The name given to the mountainous masses of ice often found floating in the polar seas. Sometimes they are formed by the breaking up of the ice-pack; at other times they have been originally portions of glaciers launched from icebound coasts into the ocean, and there further augmented by numbers of them freezing *en masse*. Icebergs have been seen in the Arctic and Antarctic Oceans several miles in circumference, rising from 40 to 200 feet above the water, and loaded with blocks of rock and masses of shingle. Some idea of their size may be formed from the fact that little more than an eighth of their bulk rises above the surface. As they are floated by the polar currents to warmer latitudes they melt away, dropping their burdens of boulder and rock-debris on the bottom of the ocean.

ICE-FLOE (Dan. ice-island).—Applied by voyagers to the smaller masses of ice that encumber the polar seas.

INDIGENOUS (Lat. native).—Applied to the plants and animals that naturally belong to a country or region. Not *exotic*, or introduced by artificial means.

ISLANDS (Lat. *insula*) occur either singly, when they are said to be *independent*; or in groups or clusters, when they constitute *archipelagoes*. They are also distinguished as continental and oceanic—*continental*, when their proximity, geological character, and axial

connection show them to be dependencies of the continent; and *oceanic*, when, far off in the ocean, they rise up independently, and are generally of volcanic or coralline formation.

ISOCEIMAL or **ISOCEIMONAL** (Gr. *isos*, and *cheima*, winter).—Having the same winter temperature: hence *isoceimal lines* are those drawn through such places as have the same mean winter temperature.

ISOGOTHERMAL (Gr. *isos*, *ge*, the earth, and *therme*, heat).—Applied to lines or divisions in the earth's crust which have the same mean annual temperature, and employed as being more definite than *isothermal*, inasmuch as it refers solely to the land, whereas an isothermal applies equally to air, land, and water.

ISOTHERAL (Gr. *isos*, and *theros*, summer).—Having the same summer temperature; *isothermal lines*, lines connecting all those places on the surface of the globe which have the same mean summer temperature.

ISOTHERMAL (Gr. *isos*, and *therme*, heat).—Having the same temperature; of equal temperature. In Physical Geography, *isothermal lines* are lines connecting all those places on the surface of the globe which have the same mean temperature; and as temperature is governed by relative distribution of land and water, by altitude and other conditions, places on the same parallels of latitude are often on very different isothermal lines.

K

KAIMS or **KAMES**.—A term applied in Scotland to those long, often tortuous and flat-topped, mounds of sand and gravel which occur in lower portions of river plains and valleys. Known as *Eskars* in Ireland and *Osars* in Sweden, and usually ascribed to the Glacial period.—See *Osar*.

Karoo.—A term applied to the open clayey flats of Southern Africa, which often rise terrace-like to considerable

elevations, and are hard and steppe-like in the dry season, but in the wet season are speedily transformed into grassy, flower-beapangled plains. The term is thought to be derived from the Hottentot word *Karusa*, signifying "hard," and to refer to the quality of the red clayey soil, which, being impregnated with iron and mixed with sand, becomes hard as burnt clay under the influence of continued drought.

L

- LACUSTRINE** (Lat. *lacus*, a lake).—Of or belonging to a lake; used in contradistinction to fluvial and marine.
- LAGOON or LAGUNE** (Ital. *laguna*).—Generally applied, as in the Adriatic, to shallow salt-water lakes or sheets of water cut off (or nearly so) from the sea by intervening strips of beach or river-deposit; also to the waters enclosed by circular coral-reefs; as well as to the lake-like sheets that frequently occur in tidal and periodically-inundated deltas.
- LAMINARIAN ZONE** (*laminaria*, the sea-tangle).—That zone or belt of marine life which commences at low-water mark, and extends to a depth from forty to ninety feet, and in British seas is characterised, as its name implies, by the broad waving sea-tangle and larger algæ, by star-fishes, the common echinus, by tubularia, modiola, and pullastra.—See Zone.
- LANDES** (Fr.).—Literally, *heaths*; but applied in particular by French writers to those extensive areas of sand-drift which stretch southward from the mouth of the Garonne along the Bay of Biscay, and inwards towards Bordeaux—hence often spoken of as the “Landes de Bordeaux.” They are extensively planted with the sea-pine (*Pinus maritimus*) on the seaward side, but stretch away inland in heathy undulating plains, chiefly occupied as sheep-runs.
- LAND-LOCKED**.—Applied to seas that are isolated from the rest of the ocean by peninsulas and chains of islands, as the Sea of Japan, the Sea of Okhotsk, &c. *Land-locked* seas are thus only partially enclosed or locked in by the land, while *inland* seas are surrounded on all sides by the land in a continuous manner, as the Baltic and Mediterranean.
- LANDSLIP**.—Any portion of high land that has slidden down to a lower level in consequence of some undermining or disturbing action. Landslips, as might be expected, are most frequent in districts subjected to earthquake disturbance, and there they sometimes take place on such a scale as materially to affect the surface configuration of the country.
- LAPILLI** (Lat. *lapillus*, a little stone).—A peculiar variety of volcanic ashes and stones, abundant in some volcanic districts, and usually forming loose bare slopes inimical to anything like vegetation.
- LATITUDE** (Lat. *latitudo*, breadth).—The latitude of a place on the earth's surface is its distance from the equator, measured in degrees, minutes, and seconds along its own meridian. If in the northern hemisphere, it is said to be in North Latitude (N. lat.); and if in the southern, in South Latitude (S. lat.). As the distance between the equator and either of the poles is only the fourth part of the earth's circumference, or 90°, the latitude of a place can never exceed that amount. *Parallels of latitude* are circles drawn parallel to the equator; and in such a circle every place has, of course, the same latitude. The terms *longitude* and *latitude* arose from a notion of the ancients that the earth was longer from east to west than from south to north; in other words, that it had *length* and *breadth*, which these terms express.
- LEEWARD**.—A nautical term of frequent occurrence in geographical descriptions. In sailing, that side of a ship against which the wind blows is called her *weather-side*, while the opposite one is known as the *lee-side*. All objects on the weather-side are said to be to the *windward*, and those on the lee-side to be to the *leeward* of the vessel.
- LICKS**.—An American term for swampy or boggy areas surrounding saline springs, the soil of which being impregnated with salt, or covered with saline incrustations, is *licked* by the wild cattle for the sake of the salt.
- LITTORAL** (Lat. *litus*, the sea-shore).—Belonging to, inhabiting, or taking place on the shore. Applied to operations, deposits, life, and other features which occur near the shore, in contradistinction to those of a deep-water or oceanic character.
- LITTORAL ZONE** (Lat. *litus*, the shore).—That zone of marine life which lies between high and low water mark (varying in extent according to the rise and fall of the tide, and the shallowness of the shore), and which in British seas is characterised, as the bottom may be rocky, sandy, or muddy, by such mollusca as the periwinkle, limpet, mussel, cockle, razor-shell, &c., and by such plants as the bladder-wrack, dulse, and carageen.—See Zone.
- LLANOS** (Span.).—The flat treeless plains that extend along the banks of the Orinoco. They are, for the most part, within the tropics, and during one-half of the year are covered with tall grasses, and for the rest desolate. They are of recent alluvial growth, and large areas

being inundated during the rainy season, they are partly still in progress of formation.

LONGITUDE (Lat. *longitudo*, length).—The distance of a place measured in degrees, minutes, and seconds, east or west of any fixed meridian. In Britain,

the fixed meridian is that of the Observatory of Greenwich; and in other countries it is usually that of their capitals. If the place be east of the fixed meridian, it is said to be in E. Long., and if west, in W. Long.—See Latitude.

M

MESOZOIC (Gr. *mesos*, middle, and *zoe*, life).—The great division of stratified groups holding the middle forms of life, as differing from the Palæozoic and Cænozoic.

METAMORPHIC (Gr. *meta*, change, and *morphê*, form).—A term applied to those rocks which have been so altered by heat, &c., that their original features are wholly or largely obliterated, or only recognisable with difficulty.

METEORIC (Gr. *meteoros*, raised above the earth).—Of or belonging to the atmosphere; and used as synonymous with *atmospheric*.

METEORIC STONES or **METEORITES** (Gr. *meteoros*, floating in the air).—See *Aerolite*.

MILE.—A well-known unit of measure, of which there are two kinds—1. The *Geographical* or *Nautical mile*, 60 of which are equal to one degree of latitude; and 2. The *common* or *statute mile*, about 69½ of which are equal to one degree. The geographical mile is about 6079 English feet; the statute mile 5280 feet.

MIRAGE (Fr.).—A meteorological phenomenon occurring most frequently on level tracts and during hot weather, and occasioned partly by the unequal rarefaction of the vapour of the atmosphere, and partly by the intermixture of strata of air having different temperatures and densities. It assumes the appearance of a lake-like sheet of water, often exhibiting the reflected or inverted images of distant objects.—See *Fata Morgana*.

MIST.—The term applied to atmospheric vapour when it becomes visible in consequence of a reduction of the temperature of the air. *Mists*, *fogs*, *hazars*, and the like, are common phenomena in insular and estuary-intersected countries like Great Britain and Ireland.

MOLLUSCS, **MOLLUSCA** (Lat. *mollis*, soft).—One of Cuvier's grand divisions of the animal kingdom, including all the "shell-fish" proper, and having reference to the circumstance that these creatures have *soft* bodies, unsupported by any internal or tegumentary framework of sufficient density to merit the name of skeleton.

MONOCOTYLEDONOUS (Gr. *monos*, one, and *kotylêdon*, seed-lobe).—Plants whose fruit has only one seed-lobe, and consequently *endogenous* in growth, like palms, lilies, grasses, &c.

MONSOONS (Arabic, *moussin*, season).—The periodical or seasonal winds of the Indian Ocean—the south-west monsoon blowing, in general terms, from April to October; and the north-east, from October to April. The alternate heating and cooling of the Asiatic continent during the southern and northern summer is the prime producer of this periodical air-current.

MORAINES.—The name given in Switzerland to the mounds of stony detritus which occur at the bases and along the edges of all the great glaciers. The glacier itself is continually moving downwards, and the rocks and stones which fall upon it from the sides of the gorge in which it lies are accumulated upon its surface in longitudinal ridges or moraines, and gradually carried downwards to the foot of the glacier. In the higher valleys there are but two of these moraines—*lateral moraines*—on opposite sides of the glacier. Where two glaciers unite, their nearest lateral moraines merge into one, and form a central or *medial moraine* upon the united mass of the lower glacier. At the point where the glacier becomes finally melted, the rocky material brought down is accumulated in transverse mounds, which are known as *terminal moraines*.

MOUNTAIN (Lat. *mons*).—Any portion of the earth's crust rising considerably above the surrounding surface. The term is usually applied to heights of more than 2000 feet, all beneath that amount being regarded as *hills*, and when of inconsiderable height, as *hills*. A *mountain-chain* or *mountain-range* is a series of elevations having their bases in contact, and their axes continuous over a considerable extent of country; while several ranges possessing a certain degree of parallelism, and evidently dependent on the same series of elevatory forces, constitute a *mountain-system*.

N

NADIR (Arabic, down).—As the *zenith* is that point of the heavens directly above the head of a spectator, so the *nadir* is that point diametrically opposite, or vertically beneath his feet. In other words, they are the opposite poles of the visible horizon.

NESS, NAES, or NAZE, literally *nose*.—Any promontory or sudden projection of the land into the sea; as Dungeness, Fifeness, the "Naze," &c.

NÈVE.—A term applied to the collected snow, or firn, of Alpine heights, before it is fully compressed into the ice of the glacier.

NODES (Lat. *nodus*, a knot).—In astro-

nomy, the points where the orbit of a planet cuts the plane of the ecliptic; or generally, the points where the orbit of one planet cuts or crosses the orbit of another.

NORMAL (Lat. *norma*, a rule).—According to rule or law; obeying what is believed to be the natural law; occurring in the ordinary course of nature.

NULLAH.—A Hindostanee term for those streams, or rather stream-courses, which are mountain-torrents during the rainy season, and during the rest of the year are dry gravelly channels, with here and there a trickling of water.

O

OASIS (Egypt. *huasis*).—In Physical Geography, a green and fertile spot in a desert; adopted from the Egyptian by Herodotus, and applied to the patches of vegetation which occur around springs in the Libyan desert.

Ooze (Anglo-Saxon, *wase*, mud).—The name applied to the soft muddy or slimy calcareous deposits found upon the ocean floor at vast depths and great distances from land, as the *Globigerina ooze*, *Rhizopod ooze*, &c.

ORBIT (Lat. *orbita*, a track or path).—The course or path of a planet round the sun; generally, the course or path described by any of the heavenly bodies. The term is derived from the Latin word *orbis*, a globe or circle; hence the

heavenly bodies are spoken of as *orbs*, and their courses as *orbits*, though, strictly speaking, their form is merely *spheroidal*, and their courses *elliptical*.

OROGRAPHY, OROLOGY (Gr. *oros*, a mountain).—The science which describes or treats of the mountains and mountain-systems of the globe.

OS or OSAR.—A Swedish term for those elongated hillocks or mounds of gravel belonging to the Drift or Glacial period, and which are abundantly and characteristically scattered over Sweden and the islands of the Baltic. The greater part of the gravel of these hills, which occasionally rise to 100 or 200 feet, is of small dimensions, and mixed with much sand.

P

PALÆOZOIC (Gr. *palaïos*, ancient, and *zoe*, life).—The lowest division of stratified groups as holding the most ancient forms of life, in contradistinction to the *mesozoic* and *catinozoic*.

PALUSTRAL (Lat. *palus*, a marsh).—Of or belonging to marshy grounds. Generally applied to plants that flourish in moist or marshy stations.

PAMPAS.—The vast treeless plains of the Paraguay and La Plata in South America, stretching from the eastern ridge of the Andes to the shores of Buenos Ayres, and thence southwards into the deserts of Patagonia. Though treeless, they are covered with luxuriant herbage—tall grasses and thistles—and are pastured by vast herds of wild cattle and horses.

PAMPERO.—The name given in Buenos Ayres to a violent west wind, which,

traversing the arid plains of the Pampas, raises whirl-clouds of dust, and carries them forward to the coast of the Atlantic. It is of brief duration, as a rule lasting only a quarter of an hour, but on rare occasions it prevails for two or three days.

PELAGIC (Gr. *pelagos*, the deep sea).—Of or belonging to the deep sea, as distinct from littoral or estuarine.

PERIGEE (Gr. *peri*, around, about, and *ge*, the earth).—That point of a planet's orbit at which it is nearest to the earth; its *apogee* being the point at which it is farthest off.

PLATEAU (Fr.).—Literally, a platform; introduced by the French geographer Buache, and applied to any elevated and comparatively flat surface of land; a *table-land* or high level region.

PLUVIOMETER (Lat. *pluvius*, rain, *met*.

ron, a measure).—An instrument for catching falling rain, so as to determine the amount that falls at any given locality within a given period; a rain-gauge, of which there are several varieties in use by meteorologists.

POLDERS (Dutch).—The name given in Holland to the low fertile lands reclaimed by vast systems of dykes and embankments from the sea. The soil of the *polders* consists of muddy deposits, mixed with comminuted shells and fine sea-sand; in other words, it is a fine marine silt, rendered fertile by the abundance of its organic debris.

POLES (Gr. *poleo*, I turn).—The extremities of the axis or imaginary line round which the earth turns in her daily rotation. They are respectively the North and South, or the *Arctic* and *Antarctic Poles*; and the districts therewith connected are known as the *Polar Regions*. By prolonging the earth's axis towards the apparent celestial concavity in which the earth rotates, we form, in like manner, the *Poles of the Heavens*, north and south; and hence the *Pole*, or *Polar Star*, from its proximity to the pole of the heavenly vault.

PORTAGE (Fr.).—Applied by *voyageurs* to the space or watershed that lies between the navigable branches of rivers

belonging to the same or different hydrographic basins, and so called from the circumstance that boats and goods have to be carried from the one branch to the other. The name is also given to those parts where, in order to avoid cataracts or dangerous rapids, the boats are unloaded, taken out of the water, carried above the obstruction, and again launched and loaded.

PRAIRIES.—The open, slightly undulating, and grassy plains of North America. Situated in the Great Central Plain, the prairies are of vast extent; some are rolling, others are flat and level in surface; many of them are treeless, and covered only with luxuriant grass and flowers; towards the south some tracts verge into a shrubby woodland, while in the extreme north the soil is largely swampy and desert.

PRIMARY (Lat. *primus*, first).—The name applied to all the fossiliferous geological systems of older date than the Triassic.

PUNA (Span.).—The term applied to the dry cold winds of the Upper Andes, whose desiccating effects are such as to shrivel up animal bodies into a kind of mummy, and so prevent their putrefaction and decay.

R

RAIN-GAUGE.—An instrument, of which there are several kinds, for ascertaining the amount of rainfall in any given locality.

RAVINE (Lat. *ravio*, I sound hoarsely).—A deep precipitous gorge, usually the narrow excavated channel of some mountain stream, and so called from the hollow murmur of its waters.

RECENT (Lat. *recens*, fresh, still growing).—In geological classification the term *Recent* is applied to all accumulations and deposits which have taken place during the human epoch, or are still in progress of formation. All accumulations and deposits whose sub-fossil remains belong exclusively to species still existing, are, geologically speaking, "recent," though chronologically they may be of vast antiquity.

REEF (Sax.).—A riff or ridge, usually applied to a range or ledge of rocks occurring in the sea, and only partially covered, or placed at no great depth under the surface of the water; e.g., the "coral-reefs" of the Southern Ocean.

REGION.—A term often loosely applied in geography, but applicable to any large tract of sea or land which is characterised by some feature—physical or vital—not occurring in other areas.

RIVER (Lat. *rivus*, Gr. *reo*, I flow).—The usual name for all considerable bodies of running water that traverse the land—*streams*, *runnels*, *rivulets*, and the like, being the terms for the minor flows that feed the main river-current. *River-basin*, the whole extent of valley-shaped or basin-shaped country drained by any river and its tributaries; e.g., the "basin of the Severn," the "basin of the Tay," &c. *River-plain*, any comparatively level and extensive tract traversed by one or more rivers, and apparently for the most part of alluvial origin.

ROADSTEAD or **ROADS**.—Usually applied to an open and exposed anchorage, where ships may ride under the lee or shelter of the land, but from which they must sail when the wind is about to blow strong from the sea.

S

- SALINAS.**—The name given in South America to those superficial deposits which often occupy extensive terraced plains on the Pacific or rainless side of the Andes, and which are usually covered with a white saline efflorescence. They occur at all elevations, from a few feet to several thousand feet above the sea-level, and are evidently the remains of upheaved sea-reaches and lagoons.
- SALINE** (Lat. *sal*, salt).—Impregnated with salt, as "saline springs." *Saliferous*, containing or yielding salt, like the "saliferous strata" of Cheshire, in England.
- SAVANNAH or SAVANNA** (Fr.)—An American term for any vast grassy plain or *prairie*; but usually applied to the great central plain of North America, which may be said to stretch, with little perceptible interruption, from the Gulf of Mexico to the Arctic Ocean.
- SCAR or SCAUR** (Sax.)—Any bluff precipice of rock, like the limestone "scars" of north-western Yorkshire.
- SCARPED** (Fr. *escarper*, to cut steep).—Having a steep face; worn or cut away so as to present a steep precipitous front like many cliffs and mountains. Hence the term *scarp* and *counter-scarp*, or *slope* and *counter-slope*, which see.
- SCORIÆ** (Ital. *scoria*, dross).—Applied to all accumulations of dust, ashes, cinders, and other loose fragments of rocks discharged from active volcanoes, and often presenting whole mountain-sides of barren, clinkery surface.
- SCORIFORM.**—In the form of, or resembling *scoriæ*. Applied to loose cindery aggregations, occurring in volcanic districts, and evidently of igneous origin.
- SECONDARY** (Lat. *secundus*, from *sequor*, to follow).—The general title of all the geological systems between the *Triassic* and *Cretaceous*, both inclusive.
- SILT.**—This term is properly applied to the fine impalpable mud which collects in lakes and estuaries, but is generally used to designate all calm and gradual deposits of mud, clay, or sand; hence we speak of "marine silt," "tidal silt," and of harbours being partially filled or *silted up* with tidal debris.
- SILVAS or SELVAS** (Lat. *silva*, a wood).—A term applied to the woodland regions of the great Amazonian plain. Low-lying, damp, fertile in soil, and under the influences of a tropical sun, these *silvas* present the rankest luxuriance of primeval forest-growth.
- SIMOOM.**—An Arabic term signifying *poison*, and applied to a hot suffocating wind, which occurs in most countries bordering on sandy deserts. Coming from the arid deserts, and laden with the minutest particles, it often gives a red or reddish-dun colour to the atmosphere, and thus forewarns the traveller to take shelter from the approach of its pestilential breath. In Turkey it is called the *Sameli*; in Egypt *Kham-sia* (fifty), because it usually continues fifty days; and on the western coast of Africa, *Harmattan*.
- SIROCCO** (Arab.)—The name given to the hot parching wind which occasionally passes over Sicily and adjacent districts, and which is supposed to originate in the Sahara or Great Burning Desert of Africa.
- SLOPE and COUNTER-SLOPE.**—The majority of mountain-chains present on one side a long and gentle slope, and on the other a short and rapid one—the former is termed the *slope*, the latter the *counter-slope*. Thus the slope of the Andes is towards the Atlantic, the counter-slope towards the Pacific.
- SNOW-BLANKET.**—The name given by farmers and others to any considerable thickness of snow which covers the ground during winter, and helps to protect its vegetation from the severity of the frost. In continental countries, like central and northern Europe, this *blanket* is of essential service during severe and long-continued frosts in early spring.
- SNOW-LIGHT or SNOW-BLINK.**—The name given by voyagers and travellers in the arctic regions to the peculiar reflection that arises from fields of ice or snow. An experienced seaman, it is said, can readily distinguish by the *blink* whether the ice is newly-formed, heavy, compact, or open. The blink or snow-light of field-ice is the most lucid, and is tinged with yellow; of packed ice it is pure white: ice newly formed has a greyish blink, and a deep yellow tint indicates snow on land.
- SNOW-LINE.**—That line or limit of elevation at which the air permanently attains the temperature of freezing water, and at and above which the surface is perpetually covered with snow and ice. The snow line is, of course, highest towards the equator, and gradually descends as we approach either pole.
- SOLANO** (Lat. *sol*, the sun).—A hot south-west wind which occasionally visits the Spanish peninsula, and, blowing from the direction of the African des-

erts, is regarded as a modified *sirocco*, which see.

SOLFATARA (Ital. *solfo*, sulphur).—A volcanic fissure or other orifice from which sulphureous vapours, hot mud, and steam are emitted; akin to the *fumeroles*, *hornitos*, *hervideros*, and *salses* that occur in most volcanic areas.

SOLSTICES (Lat. *sol*, the sun; *sto*, I stand).

—The two extreme points of the sun's apparent course north and south of the equator, and where he appears for a time to make a stand, going neither northward nor southward. These are the first points of Cancer and of Capricorn, and the two corresponding seasons of the year are known as the *Summer* and *Winter Solstices*.

SPECIES (Lat. *specio*, to look).—The name given by biologists to each group of animals or plants which possess so many characters in common that they may reasonably be supposed to be descended from a single pair. The subdivisions of species are *varieties* and *races*.

SPECIFIC HEAT.—Different bodies require different amounts of heat to raise them through the same range of temperature; in other words, different bodies appear to possess different capacities for heat. Thus the amount of heat necessary to raise a pound of water 100° will raise 31 lb. of platinum through the same range of temperature. This relation is expressed by saying that the *specific heat* of platinum is $\frac{1}{31}$, or 0.032—the specific heat of water being taken as the unit.

SPOONDRIFT.—During storms at sea, the violence of the tempest is sometimes so intense as to quell the billows, and scatter the water in a heavy shower, called by the sailors *spoon-drift*. On such occasions saline particles have impregnated the air to the distance of fifty miles inland.

STATION.—The region occupied by any particular plant is called its *station*, and that of any particular animal its *habitat*—each being the locality which presents the conditions most favourable to its growth and development.

STEPPES.—A Tartar term, adopted by geographers for those extensive flats or

plains which occupy so large a portion of Northern Asia and Siberia. They are generally covered with long rough grass, are but partially wooded, and consist of alluvial deposits (sand, gravel, black-earth, hog-earth, &c.), all of comparatively recent formation.

SUB-AERIAL.—Literally "under the air;" applied to phenomena which take place on the earth's surface or under the open air, in contradistinction to *sub-aqueous* or under the water.

SUB-AQUEOUS (Lat. *sub*, under; *aqu*, water).—Applied to phenomena that take place in or under the water, in contradistinction to *sub-aerial*, or those that take place under the open air.

SUBMARINE (Lat. *sub*, under, and *mar*, the sea).—Under the sea: applied to objects that have their place at some depth in the waters of the sea, at the bottom of the ocean, or covered by the waters of the ocean; as "submarine forests," "submarine volcanoes," and other analogous phenomena.

SUBMERGENCE (Lat. *submergo*, I plunge under water).—Applied to all sinkings of the land whereby its surface is brought under the waters of the ocean. Thus we have "submerged forests," "submerged islands," and so forth.

SUBSIDENCE (Lat. *sub*, under, and *sido*, I sink or settle down).—The act of sinking or settling down to a lower level. Applied in Geology to sinkings of portions of the earth's crust, which may be either gradual and scarcely perceptible over a long lapse of years, or sudden and destructive as arising from earthquake convulsions.

SURF.—The name given to the "broken water" of waves that roll and break on comparatively flat shores. The surf along certain shores in the southern hemisphere is often very violent and almost incessant.

SYSTEM (Gr. *syn*, together, and *histemi*, to stand).—Groups of objects or occurrences having such relations as permit them to be classed together, constitute a system. In Geology the name *system* is applied to any consecutive series of rock formations, united by a general community of organic remains.

T

TABLE-LAND.—Any flat or comparatively level tract of land considerably elevated above the general surface of a country. While *plains* and *valleys* are low-lying expanses but little broken by elevations and depressions, *table-lands* and *plateaux* are similar tracts, often of great altitude; e.g., the table-land of Central Spain, 2300 feet; and that of Mexico, 6000 feet above the level of the ocean.

TALUS.—The loose detritus accumulated at the base of cliffs and precipices, and derived from their withered and wasted surfaces. Where the cliffs are high, and the rocks of a wasting nature, the talus in the course of ages assumes gigantic dimensions, and its long sloping surface becomes a characteristic feature in the landscape.

TERRACE.—Any shelf or bank of land

having a uniformly flat or level surface. Such terraces are produced by the operations of water, and are either ancient sea-margins (*raised beaches*), or lake and river terraces; and point to a time when the valleys in which they occur were either occupied by lakes at these heights, or had their flooded surfaces at these levels, before their rivers had worn their channels down to lower depths.

TERTIARY (Lat. *tertius*, third).—The name given by geologists to the third cycle of fossiliferous rocks, or those which succeed to the chalk and are followed in turn by the deposits now in process of formation.

THERMAL (Gr. *therme*, heat).—Applied to hot springs and other waters whose temperature exceeds that of 60° Fahr.

TIDES.—The name given to those regular oscillations, or risings and fallings of the water of the ocean, which are occasioned by the attraction of the moon and sun, and which occur twice in the course of the lunar day (24 hours 54 minutes). The flow, or rising towards the shore, is called *flood tide*, and the falling away *ebb tide*. The highest point to which the flood tide attains is called *high-water*, and the lowest to which the ebb tide sinks is *low-water*. During high and low water there is a short period of rest, or no current either way, and this is called *slack-water*. When the sun and moon act in the same direction (that is, at full moon), the greatest tidal rise will take place, and these are known as *spring-tides*; but when these luminaries are in opposition (that is, during the third and first quarters of the moon), the rise is least, and then we have *neap-tides*.

TOPOGRAPHY (Gr. *topos*, a place, and *grapho*, I describe).—A particular account of any locality, city, town, or village; in contradistinction to the general *geography* of the country in which it is situated.

TORNADO (Span. *tournar*, to turn).—A whirlwind; any violent storm or hurricane of wind, usually accompanied with thunder, lightning, and rain. Tornadoes, though excessively violent and destructive, are for the most part limited in area and of short duration.

TORRID ZONE (Lat. *torridus*, burning, scorching).—The middle zone or belt of the earth's surface, extending on each

side the equator to the tropics of Cancer and Capricorn respectively; and so called from its high temperature.—*See Zone*.

TRAPPEAN.—The name applied by former geologists to the volcanic rocks associated with strata of older date than the Tertiary System; so called from their step-like aspect in the field (Swedish, *trappa*, a flight of stairs). As these rocks, though somewhat altered and different in their general appearance from modern volcanic rocks, are nevertheless of similar origin, the word *trappean* is rapidly disappearing from geological terminology, the word *volcanic* being properly applied to igneous rocks of all ages.

TRIBUTARY.—Applied to any stream which, directly or indirectly, contributes water to another stream. One stream falling directly into another stream becomes an *affluent* to that stream; but both may be *tributaries* to some larger current.

TROPICS, TROPICAL (Gr. *tropikos*, from *trepo*, I turn).—Those two circles on the earth's surface over which the sun seems directly to pass when he is at the greatest distance from the equator—viz., 23½ degrees—and so called because he *turns* alternately southward and northward on reaching these points in his apparent annual course or ecliptic. The extreme divergence of the ecliptic from the equator being marked by the constellations Cancer and Capricorn, the one circle is called the northern tropic, or Tropic of Cancer, and the other the southern, or Tropic of Capricorn. The zone or belt of the earth within these circles is said to be "within the tropics" or "*tropical*," and constitutes the Torrid Zone of climatologists. Plants, animals, climate, and other phenomena occurring within this region are said to be *Tropical*; those on the extreme temperate verges of the region, *Sub-tropical*.

TYPHOON (Gr.).—Literally, a tempest or whirlwind. *Typhoons*, the name given by navigators to the hurricanes that visit, generally from June to November, the seas of Southern China, and the adjacent archipelago of the Philippines and Moluccas. The Chinese name is *Tae-fung* or great wind, of which it is not unlikely *Typhoon* is a sailor's corruption.

V

VALLEY (Lat. *vallis*).—Any depressed or low-lying tract of land bounded by hill or mountain ranges; and usually traversed by a stream or river which receives the drainage of the surrounding

heights. We have thus "longitudinal valleys" and "transverse valleys," according to the configuration and disposition of the bounding heights; though, generally speaking, longitu-

dinal valleys, taking their names from the rivers which flow through them, are the most characteristic and common. A level tract of great extent, and traversed by more rivers than one, is, properly speaking, not a valley, but a *plain*; and deep narrow river-courses, on the other hand, are more correctly designated *glens*, *ravines*, and *gorges*.

VARIABLES.—Near the equator the trade-winds, north and south of it for a certain distance, completely neutralise each other, and the zone of calms and light breezes so formed is known as the *Variables*.

VOLCANIC (*Vulcanus*, god of fire).—Igneous action apparent at the surface

of the earth, in contradistinction to *Plutonic* (which see), or that taking place at greater depths.

VOLCANIC FOCI (Lat. *focus*, a fire, the point of greatest intensity).—Subterranean centres of igneous action from which minor exhibitions diverge.

VOLCANO (Lat. *Vulcanus*, the god of fire).—A volcano has been described by Sir Charles Lyell "as a more or less perfectly conical hill or mountain, formed by the successive accumulations of ejected matter in a state of excessive heat, and having one or more channels of communication with the interior of the earth, by which the ejections are effected."

W

WARP.—A provincial term for the muddy deposit from tidal waters over low-lying lands, such as those occurring near the Trent, Ouse, Humber, &c. The process is often artificially accelerated by embanking the land, letting in the turbid tide, impounding the waters, and then allowing them to run off by sluices after their slimy sediment has subsided.

WEATHER-GLASS.—The familiar name for the barometer, whose variations usually indicate approaching changes in the state of the weather.

WHIRLPOOL.—Any rotary or circular motion of water produced by opposing winds and tides. The whirlpool of Maelström, on the coast of Norway, is occasioned by the meeting of tidal currents round the islands of Lofoden and Moskoe. It is a mile and a half in diameter, and so violent that its roar is heard at the distance of several leagues.

WHIRLWIND.—The name given to local aerial currents that assume a rotatory, whirling, or spiral motion. They are of very insignificant diameter, rarely exceeding a hundred yards in width. The length of their course, however, is

occasionally as much as 25 miles. They are often of great violence, but fortunately of short duration, seldom lasting longer than a minute. They are most frequently caused by the meeting of two contrary winds, or by the eddies originated by the mutual interference of ascending currents of air. Their occurrence at sea produces *waterspouts*; on the loose sands of the desert, *sand-pillars*, and kindred phenomena.

WIND (Sax.).—The general name for aerial currents caused by the unequal heating of the atmosphere—the heated and more rarefied portions ascending, and the colder and denser flowing inwards to supply their place. Winds are divisible into three great categories—*permanent*, like the trade-winds; *periodical*, like the monsoons and the sea and land breezes; and *accidental*, when the times of their occurrence cannot be determined.

WINDWARD.—In nautical phraseology all objects on the weather-side of a vessel, or that against which the wind blows, are said to be to the *windward*—that is, in the direction from which the wind blows.—See *Leeward*.

Z

ZENITH (Arabic).—In Astronomy, that point in the heavens which is vertically or right above the head of the spectator; the term *nadir* being that which denotes the opposite point, or that perpendicularly or right under his feet.

ZODIAC (Gr. *zodion*, a little animal).—The name given by astronomers to the zone within which the apparent motions of the sun, moon, and all the greater planets are performed. It con-

stitutes a belt nine degrees on either side of the ecliptic, and is so named from its containing the figures of the animals, &c., which represent the twelve signs.

ZONE, in Geography (Gr. *zona*, a girdle).—One of the five great belts into which the earth is supposed to be divided in respect to temperature—viz., the *torrid*, two *temperate*, and two *frigid* zones. The torrid zone includes all the space that lies between the tropics,

or $23\frac{1}{2}$ degrees on each side of the equinoctial line; the temperate from that limit to the arctic circle ($66\frac{1}{2}$ degrees) in each hemisphere; and the frigid zones from the arctic circles to either pole.

ZONE, in Botany.—With a view to generalise their observations on the geographical distribution of indigenous plants, botanists are in the habit of dividing the horizontal range of vegetation into *zones*, bounded by annual isothermal lines, as—1, the equatorial; 2, tropical; 3, sub-tropical; 4, warmer temperate; 5, cooler temperate; 6, sub-arctic; 7, arctic; and 8, the polar. These zones being applicable to either hemisphere, express the climatic facies of vegetation within more precise limits than the three great zones—torrid, temperate, and frigid—of the geographer.

ZONE, in Zoology.—Every zone, from the shore daily covered by the tides to the greatest vital depths, being characterised by its own peculiar sea-weed and shell-fish in a manner very analogous to the changes in the forms and species of vegetation observed in the ascent of a tropical mountain, zoologists are in the habit of speaking of certain bathymetrical zones, or “zones of life regulated by depth.” Thus, in the British seas, naturalists (following the late Edward Forbes), point out *four* great belts of life—the *Littoral*, the *Laminarian*, the *Coralline*, and the *Coral* (which see); or applying the principle to the life of the ocean in general, they distinguish *five* great belts of depth—viz., 1, the *Littoral*; 2, *Circum-littoral*; 3, *Median*; 4, *Deep-sea*; and 5, the *Abyssal zone*.

E R R A T A.

Page 40, Table, for “*Pepidian*” read “*Pebidian*.”

„ 82, Ben Nevis, for “4373” read “4406.”

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* * *The figures refer to the sections of the text in which the particular term or subject occurs; G. to the Glossary, where it is still further explained.*

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